Regional Operational Plan SF.4A.2014.05

Anadromous Cataloging and Fish Inventory in Lakes Draining to Bristol Bay

by

Joseph Giefer

and

James Bales

August 2014

Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

REGIONAL OPERATIONAL PLAN SF.4A.2014.05

ANADROMOUS CATALOGING AND FISH INVENTORY IN LAKES DRAINING TO COOK INLET AND BRISTOL BAY

by

Joseph Giefer and James Bales

Alaska Department of Fish and Game, Division of Sport Fish, Anchorage

Alaska Department of Fish and Game
Division of Sport Fish

August 2014

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Joseph Giefer and James Bales,
Alaska Department of Fish and Game, Division of Sport Fish,
333 Raspberry Road, Anchorage Alaska

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SIGNATURE/TITLE PAGE

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Plan Type:	Category III

Approval

Title	Name	Signature	Date
Project leader	Joseph Giefer	Joseph Giefer	7/16/2014
Biometrician	Adam Craig		7/15/2014
Research Coordinator	Dean Hughes		7/15/14
Regional Supervisor	James Hasbrouck	James J Hasbrouck	8/7/2014

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ABSTRACT

From July 28 to August 19, 2014, the Alaska Department of Fish and Game, Division of Sport Fish will conduct an inventory of lake-fish assemblages and associated aquatic and riparian habitats in a 35,436 square kilometer study area spanning the Nushagak, Wood, and Kvichak river drainages (excluding conservation units). We identified 40 potential lake sites, from which we will select and sample 20 different lakes. Planned lake sites range in size from .27–3.11 sq.km of surface area. At each lake, prior to setting gillnets and electrofishing, we will collect data describing lake location, lake origin and type, water quality, depth, aquatic habitat, and riparian vegetation. Fish will be collected primarily using boat-mounted electrofishing gear and gillnets. Anadromous fish-assemblage information collected will be used to nominate lakes to the State of Alaska's *Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes*, or to update fish life stage information for waters already in the catalog.

Key words: fish inventory, lake survey, anadromous, Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes, Anadromous Waters Catalog, electrofishing, gill netting, minnow trap, Nushagak river drainage, Wood river drainage, Kvichak river drainage.

INTRODUCTION

The State of Alaska is committed to conserving fish and their habitat. Alaska is the only state with a constitutional mandate[1] to maintain sustained yields of fish stocks (ADCCED 2009), and the Alaska Department of Fish and Game (ADF&G) has a statutory responsibility to manage the use of wild fish stocks for sustained yield (AS 16.05.730(a)). Along with proper management of harvests, protection of fully functioning and connected aquatic habitats is necessary to sustain fish stocks supporting Alaska's commercial, subsistence, and recreational fishing economies.

The state has multiple administrative tools to protect fish habitat. Alaska Statute (AS) 16.05.871 (the Anadromous Fish Act), along with the Fishway Act (AS 16.05.841, which requires that fish passage be maintained in any stream "frequented by salmon or other fish"), constitute Alaska's strongest and most comprehensive instream fish habitat protection standards. Several other Alaska statutes specifically reference fish habitat, including multiple sections in AS 41.17 (Forest Resources and Practices Act) and AS 46.15 (Water Use Act), both administered by the Department of Natural Resources, and AS 46.03.758 (Civil penalties for discharges of oil), administered by the Department of Environmental Conservation.

The Anadromous Fish Act requires ADF&G to "specify the various rivers, lakes and streams or parts of them" of the state that are important to the spawning, rearing or migration of anadromous fish. The *Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes* (Anadromous Waters Catalog, AWC) and its associated atlas are the media used to accomplish this specification, and are adopted as regulation under 5 AAC 95.011. Activities and uses conducted in, or otherwise affecting, either any AWC listed water bodies (under the Anadromous Fish Act), or fish passage in any fish-bearing waters (under the Fishway Act) statewide, require prior approval from the ADF&G Division of Habitat, which is responsible for reviewing project plans and specifications submitted by permit applicants. Permitting biologists work closely with project applicants to ensure that project plans provide for the proper protection of fish habitat. If so, a Fish Habitat Permit is issued authorizing the activity. Permit applications may be denied if impacts to fish habitat cannot be adequately avoided, minimized, or mitigated.

[1] The Constitution of the State of Alaska; Article 8, Section 4 – Sustained Yield states "Fish, forests, wildlife, grasslands, and all other replenishable resources belonging to the State shall be utilized, developed, and maintained on the sustained yield principle, subject to preferences among beneficial uses."

Many other federal, state, and local government policies specify additional protections for anadromous fish habitat in Alaska. Like the Anadromous Fish Act, these only apply to those waters where anadromous fish use is explicitly documented, typically by reference to the AWC. For example, the National Marine Fisheries Service (NMFS) identifies Essential Fish Habitat (EFH) for Alaska stocks of Pacific Salmon in freshwater by reference to the AWC. Three of the U.S. Army Corps of Engineers' regional conditions for nationwide permits in Alaska specify additional requirements and restrictions for proposed projects located in or near AWC listed water bodies. Other policies that protect AWC listed water bodies are found in: area plans for state lands; state forest management plans; resource management plans for Bureau of Land Management (BLM) lands; federal and state regulations specifying waters closed to commercial and subsistence fishing; and city and borough ordinances.

Comprehensive fish distribution information is required for effective land use, conservation, and restoration planning to identify sensitive and important habitats. State land-management plans, such as the *Susitna Area Plan* and the *Bristol Bay Area Plan*, and more specific plans such as the *Kenai Peninsula Brown Bear Conservation Strategy*, identify management guidelines or specify geographic areas of concern based in large part on the known distribution of fish. Watershed and conservation planning efforts also rely heavily on knowledge of fish distributions and aquatic habitat characteristics and their spatial and temporal relationship to other resources and activities. Planning for habitat restoration programs, such as fish passage enhancement, is also better informed with access to comprehensive fish distribution information.

Resource developments, such as transportation and utility corridors, are most effectively informed if complete fish distribution data is available at project onset. If comprehensive fish distribution information is provided during project scoping, projects can be designed to avoid habitat impacts; however, absence of comprehensive fish distribution information can lead to unintended fish habitat impacts.

All these fish habitat conservation authorities and planning processes are limited, by the extent of current knowledge of fish habitats and their distribution. The Anadromous Fish Act, along with other federal, state, and local government policies that refer to the AWC, provides protection only to those waters identified in the AWC. Listing new water bodies in the AWC requires site specific, direct, and unambiguous observations of anadromous fish followed by a lengthy biological and public review process. Habitat modeling, speculation, or professional judgment is not sufficient to add water bodies to the AWC.

Previous field inventories have demonstrated significant data gaps in the understanding of Alaskan freshwater fish distribution and habitat characteristics. For example, recent (2003–2008) anadromous cataloging work resulted in a 75% increase in the sum of the lengths of AWC listed streams, and a 72% increase in the number of cataloged water bodies, in the Nushagak River basin.

There are approximately 1 million miles of stream and 3 million lakes in Alaska, however, the current (2014) edition of the AWC lists anadromous fish use in only 18,315 water bodies statewide (personal communication, J Johnson, ADF&G Habitat Biologist, April 2014, Anchorage, Alaska). We believe that this number represents <50% of the length and number of water bodies actually used by anadromous species. Since the state has limited authority to protect anadromous fish habitat not listed in the AWC, and because prior Alaska Freshwater Fish Inventory (AFFI) projects have, for logistical and budgetary purposes, focused on lotic (flowing water bodies [i.e., streams and rivers]) systems, nearly at the exclusion of lentic (non-flowing water bodies [i.e., lakes and ponds]) systems, we feel that there is a substantial need to more directly study the fish and aquatic habitats present in Alaska's lentic systems. This need is further emphasized by the fact that of the 18,315 water bodies currently listed in the AWC, only 1,634 are lentic systems; which again, is expected to be substantially less than half the number of these habitats that in fact directly support anadromous fish stocks.

A central goal of this project is to inventory fish assemblages, not individual species or selected species groups. We emphasize this approach for several reasons, including:

1. Although some taxa (e.g., anadromous fishes) have increased current management interest, all species trigger some regulatory processes (e.g., the Fishway Act) and are of management and scientific interest.
2. Our mix of funds target both game and non-game fish species.
3. Single-species or species-group surveys do not provide ecosystem level information. For example, patterns of individual species distribution may be a function of inter-specific relationships (e.g., competitive or predator-prey). Collecting data only on individual species precludes examination of these potential relationships.
4. It is logistically efficient. Given Alaska's vastness and remoteness, transport to sample locations often is the most difficult impediment to data collection. Therefore, the limited additional cost of collecting data on all members of the fish assemblage is small relative to the cost of traveling to study locations.

To refine fish-habitat management in specific waters, resource agencies also need knowledge of local aquatic and riparian habitat characteristics. Since aquatic and riparian habitats vary in their sensitivity to human activities, these habitat characteristics should be well understood when planning or permitting general or specific activities. Physical and biological characteristics of riparian and aquatic habitats are important factors in determining appropriate best management practices and mitigation strategies. Therefore, at each fish collection lake, we will also record parameters describing water quality, lake morphology, and aquatic and riparian vegetation communities such that sufficient information is documented to:

1. Identify well supported and adequate habitat protection stipulations for permitting of local, low level disturbances, or;
2. Identify specific further sampling needs and methods necessary to design adequate habitat protection stipulations or mitigation for permitting moderate or higher level disturbances.

Documenting aquatic and riparian habitat characteristics at fish collection lakes also provides baseline information for comparison with future studies, and may also contribute to improved understanding of fish habitat associations.

In the AFFI program, we strive to proactively prepare for management information needs. Historically, fish-habitat surveys in Alaska have focused almost exclusively on sites considered imminently threatened, or actively impacted, by human activities. While a reasonable and necessary approach, it is not a sufficient strategy to ensure the sustainability of Alaska's freshwater fish resources. With this reactive approach, fish habitat data collections and analyses often do not occur early in project development trajectories, and results may arrive too late to contribute to major management decisions, or to effectively inform project design. The historic approach of investigating only imminently-threatened or actively-impacted habitats also constrains the range of scientific inference that can be made with collected data. The whole-watershed approach for AFFI investigations complements local, site based fish studies by providing fish distribution and aquatic habitat information to decision makers early in the project scoping process and by providing baseline information to assess relationships between fish and natural habitats, unaffected by local anthropogenic habitat alterations.

In response to the above needs, in the summer of 2014, we will conduct a rapid, systematic inventory of fish distribution and associated aquatic and riparian habitat characteristics in selected Bristol Bay drainage lakes. Since 2002, we have systematically inventoried 36 of Alaska's 139 subbasins, including study areas in Cook Inlet, Bristol Bay, Seward Peninsula, Central Yukon-Tanana, Upper and Middle Kuskokwim River, Lower Yukon-Innoko, Eastern Norton Sound, and Upper Koyukuk basins.

OBJECTIVES

The overall goal of the AFFI program is to provide information needed for management of the freshwater habitats that support Alaska's anadromous and freshwater resident fish stocks. This project will contribute to that goal by achieving the following objectives:

Objective 1: To maximize the spatial increase of mapped anadromous fish habitat depicted in the AWC by completing a baseline inventory of fish (with emphasis on anadromous fish) assemblages in selected lakes within specified Cook Inlet, Bristol Bay and Alaska Peninsula drainages.

> Task 1: Locate fish collection lakes to maximize the spatial increase of specified anadromous fish habitat in targeted drainages while minimizing the number of sample lakes per drainage.
>
> Task 2: Sample each lake using standard fish collection methods.
>
> Task 3: For each lake in which anadromous fish are observed, submit a nomination to the AWC, providing sufficient information to achieve the intended result (i.e., addition, deletion, correction, or backup information).

Objective 2: To record characteristics of aquatic and riparian habitats at each lake such that sufficient information is documented to: (a) identify well supported and adequate habitat protection stipulations for permitting of local low level disturbances; or (b) identify further sampling needs necessary to design adequate habitat protection stipulations or mitigation for permitting greater levels of disturbances.

> Task 1: Record a suite of standard aquatic habitat parameters at each lake.
>
> Task 2: Characterize the dominant aquatic and riparian vegetation communities at each lake.

STUDY DESIGN

CIAP 4-YEAR STUDY AREA

In the past, AFFI study area boundaries were delineated on a year to year basis to coincide with watershed boundaries such that the spatial expanse of a single years study area could be sampled with sufficient effort to achieve our objectives as well as those of our various funding sources and project partners while staying within the logistical sideboards of the project. In contrast to these prior yearly study areas, we have, due to funding source stipulations, selected a relatively expansive 4-year study area (bound as before by drainage areas) to be iteratively visited over 4 field seasons (2012-2015). This 98,750 square-km (sq. km) study area (Figure 1) spans east to west from Anchorage to Dillingham and north to south from the Susitna River drainage to Cold Bay, excluding conservation units. Due to the vastness of this 4-year study area, and the distances between suitable field bases (those able to provide adequate resources to address project logistics), we have divided our study area into smaller geographic areas that are most closely associated (spatially) with suitable field bases though not necessarily directly associated with drainage area boundaries as before. The result was the identification of 9 field bases (Kodiak, Moose Pass, Nikiski, Drift River, Port Alsworth, Koliganek, Dillingham, King Salmon, and Port Heiden) each to be assigned its own suite of target streams. A set of adjacent field bases and their associated target streams will be selected for investigation each field season.

This 4-year study area was selected for fish inventory fieldwork based upon: expected gaps in AWC coverage; human activities and infrastructure potentially affecting fish habitat; land conservation status; and stipulations related to funding source objectives.

2014 STUDY AREA

For investigation in 2014, a 35,436 sq. km study area was delineated around both the Koliganek and Dillingham field bases (Figure 2). For logistical reasons, the Koliganek field base was later changed to the Alagnak Lodge located near King Salmon. A set of 40 target lakes were identified within this study area for fish inventory sampling in 2014. An associated AFFI stream sampling study will also conducted in the same study area concurrently with this project.

As was mentioned above, the study area was, for logistical purposes, delineated primarily based upon proximity to the most accommodating field bases identified in the area. Using GIS applications, the following steps were taken to delineate a discreet 2014 Study Area: From the 4-year Study Area, several HUC8s (4^{th} level Hydrologic Unit Codes; subbasins) (19030206, 19030301, 19030302, 19030303, 19030304, 19030305, and 19030306) were identified to most closely encapsulate the 2014 field bases and all of their associated target lakes. For the most part this 2014 study area does in fact follow watershed boundaries, however Hydrologic Unit 19030206 (Lake Iliamna) was split such that target lakes could be associated with the most appropriate (nearest) field camp (in 2012, 2013 and 2015).

2014 FIELDWORK DATES

See Table 4. The Alagnak Lodge based fieldwork is planned for July 28–August 8 and the Dillingham based field trip is planned for August 9-19, 2014.

By conducting fieldwork in July and August, we believe we will maximize our ability to observe a variety of anadromous fishes, especially freshwater rearing species and life stages, at or near the upstream limits of their range, in order to achieve Objective 1. Anadromous fishes rearing in freshwater environments (i.e., mainly age-0 and age-1 coho Chinook and sockeye salmon) are presumed to be at or near their maximum upstream distribution in the study area during July–August, after they emerge and disperse from their natal habitats, but prior to the onset of rapidly cooling waters in the fall, when they likely begin moving to their winter habitats.

2014 TARGET LAKE SELECTION

One lake team (Team B) transported by chartered float plane will visit target lakes within the study area for a total of 20 field days split between the Alagnak Lodge and Dillingham bases. For logistical reasons, this crew will visit 1 target lake per day.

Prior to the 2014 field season, we identified 39,231 potential target lakes in our 2014 study area from the National Hydrologic Dataset (NHD). In an attempt to target only those lakes that would optimize our ability to accomplish the goals of this project, we selected a prioritized sub-set of these lakes to be considered for investigation using the following GIS based filters:

1. Only lakes intersected by a NHD arc connecting to the ocean were retained. Lakes without accessibility to river systems are not accessible to anadromous species and are typically not expected to support as diverse of fish assemblages as those that connect.
2. Only lakes over 0.25 sq. km were retained. Lakes smaller than 0.25 sq. km may be too small to access with a float plane.
3. Only lakes that are not currently listed in the AWC were retained. With the number of potential study lakes in the study area, those that have already been documented to support anadromous species are of low priority relative to those that have not been documented.
4. Only the largest remaining lake in each HUC 6 was included in our set of potential sample lakes. In this study area, many of the lakes are closely clustered and connected by surface flow and would therefore likely support similar fish communities. Therefore, we felt that sampling only one lake per HUC 6 would be the most efficient way to maximize AWC additions. It is assumed that in general, larger lakes are capable of supporting more diverse fish assemblages than smaller lakes.
5. Since anadromous cataloging is the primary objective of this project, any lakes located upstream of documented fish passage barriers were removed from consideration.

We do not understand enough about the ecological factors that may limit anadromous fish distribution in the study area to implement additional filters (e.g., elevation, trophic phase, etc.) in our target lake selection process. We did remove from consideration a few lakes that ranked high after this filtering, but that despite its large surface area, are shaped in a way that precludes a float plane from landing on the lake, as well as a few water bodies identified in the NHD as lakes but which are actually oxbows and side slews of a nearby river.

After applying those filters to the original list of potential target lakes, we then ranked the results based on distance of the lake from the current AWC coverage, with lakes farther from the AWC coverage getting a higher rank. This resulted in the selection of 40 potential target lakes in a ranked order that we intend to sample in 2014 (Appendix C1). We ranked and selected approximately two times as many lakes as we have field days, to have enough extra lakes for alternative site locations due to changes made in the field due to many different reasons, i.e. weather, ability to land a float plane, depth, etc.

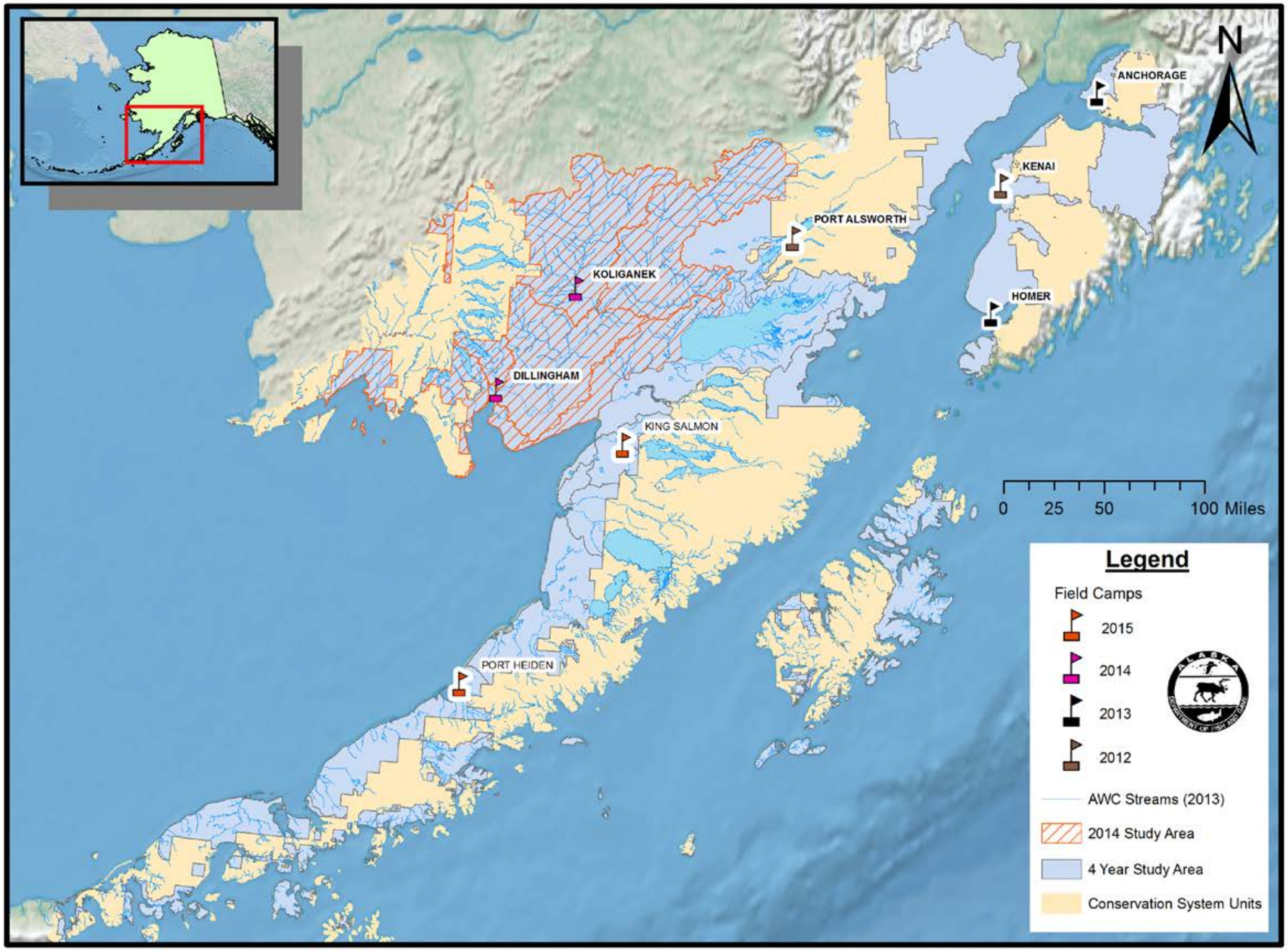

Figure 1.–CIAP 4-year study area map.

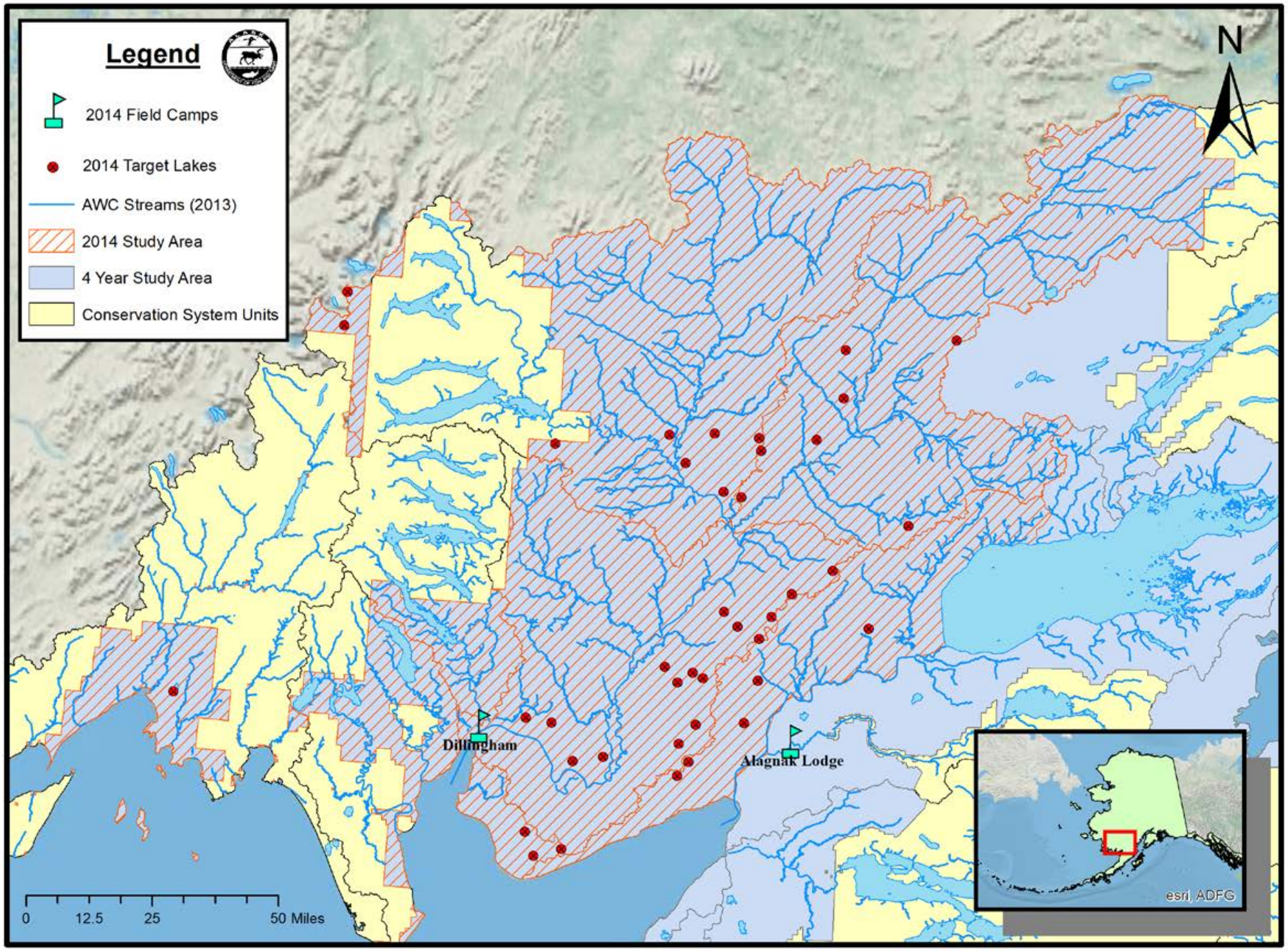

Figure 2.–2014 study area and target lake map.

FISH-COLLECTION SITES

Sampling gear and effort

Vaux et al. (2000) found that three or four electrofishing transects of 4-minute duration were sufficient to collect a reasonably complete sample (79%) of the available species pool in lakes smaller than 20 hectares (ha, 0.2 sq. km). However, in larger lakes up to 900 ha (9 sq. km), as many as nine transects were required to achieve a similar degree of sampling sufficiency. Knowing that electrofishing is seldom effective in water depths of over 2 m (Hartley 1980; CEN [Comité Européen de Normalisation] 2005) and when targeting highly mobile species such as salmonids (Vaux et.al 2000), we will also employ benthic gillnetting as a secondary method to target species that are expected to be underrepresented by electrofishing. Gillnets perform well in capturing both roaming and pelagic species (e.g., salmonids, Vaux et al. 2000) and are therefore well suited as a supplementary capture method for our project.

Fish-collection sites in lakes

The lake team will initially navigate to the lake outlet point and then circle the lake at a low level to identify a location to serve as a base for the sampling effort in the vicinity of areas expected to provide the most desirable fish sampling attributes (i.e., habitat diversity). As the plane circles the target lake, the crew leader will evaluate its aquatic habitat and hydrologic layout, paying particular attention to relative depths, substrate, vegetation, inlets and outlets, and sampling hazards. The crew leader will select a base location meeting the following criteria:

1. a location that can be safely accessed by float plane;
2. a location where the crew leader anticipates having the highest fish sampling efficiency, based on observable characteristics including: fish observed from the air; juxtaposition of aquatic habitat types; and accumulated experience in evaluating the presence of anadromous fish in adjacent and similar water bodies;
3. where prior approval to access private, native, military, or municipal lands has been provided (unless all activities can be conducted within the bounds of the ordinary high water level, in which case no access permission is needed, except for sites located within restricted military land or airspace).

In some cases, the crew leader may judge that the target lake is not likely to provide anadromous fish habitat, and that the objective of maximizing the increase in length of AWC listed anadromous fish habitat would be better served by devoting effort elsewhere. In such cases, the crew leader will take aerial photograph(s) of the lake along with notes describing the unfavorable conditions prior to directing the pilot to the next target lake.

STATIONS, WAYPOINTS, AND VISITS

At each study lake a GPS waypoint will be marked at the bathymetric sample location (described in the Aquatic and Riparian Habitat Assessment section of this document). We will refer to this point as the Station. If fish sampling is attempted, we will also mark a waypoint at the beginning and end of each electrofished transect, as well as a waypoint at each gillnet set site. If a fish collection event is established without a bathymetric site, the location of the fish collection event will serve as the Station location.

We may also establish a Station at sites with no bathymetric sample location and no fish collection sites—such as: target lake lacking a suitable landing zone; target lake deemed unlikely to support anadromous fish use; target lake upstream of waterfalls or other definite migratory barriers (Appendix B3). In cases such as these, photos will be taken of the lake and items of interest and comments will be recorded describing the reason for its exclusion.

We will assign a unique 5-character alphanumeric identifier (Station ID) to each Station. Any observations recorded in the project database must be associated with a Station ID. The structure of the Station ID will be:

1. the first 2 characters will represent the sequential survey day (e.g., 01, 02…)
2. the third character will represent the team making the observation (e.g., A, B, …). For this project, the lake team will be designated as Team "B".
3. the fourth and fifth characters (e.g., 01, 02, …) will represent the sequential Station number visited on a given survey day. Note that the Station number (4^{th} and 5^{th} characters of the Station ID) will begin at 01 at the start of each survey day.

For example, Station 04A01 will be the 1^{st} Station visited by Team A on the 4^{th} field day.

Data pertaining to this lake sampling project will be housed in an AFFI programs master database under a unique project code (CIA14) for all sampling completed in 2014. The combination of Project Code and Station ID therefore will ensure a universally-unique identifier for each Station.

See Table 2 for a list of variables associated with sample lakes that will be recorded at each study site.

FISH-COLLECTION METHODS

Our objective is to sample the entire fish assemblage at each study lake. Generally when sampling lake fish assemblages, it is best to use a multiple gear approach as any single gear type is not well suited for effectively targeting all species and habitats within a lake. The AFFI program strives to use standardized methods for all data collection activities, however, due to study objectives, logistical constraints, and budgetary concerns, we are somewhat restricted in our ability to use purely standardized methods and often must alter variables such as set-time, transect distance, etc. to accommodate these requirements.

Since our main objective entails sampling fish assemblages in a large number of remote lakes in a short amount of time, we selected electrofishing to be our primary sampling method. We selected this method because: 1) electrofishing typically captures more species with less size selectivity than other gear types (Hendricks et al. 1980, Vaux et al. 2000); 2) electrofishing is a safe method for biologists, and captures fishes with minimal mortality or injury to the fishes (Curry et al. 2009); 3) sample time required to capture similar numbers of species and individuals at a given location is less with electrofishing than with passive methods (Vaux et al. 2000).

We realize however, that active gear types (i.e., electrofishers) are less effective at capturing mobile species (i.e., many salmonids) (Lapointe, et al. 2006; Hubert 1996; Reynolds 1996) than passive gear types (i.e., gill nets), and that electrofishing is ineffective in deep water (typically over 2 m) (Hartley, 1980; CEN, 2005). For these reasons we intend to supplement our electrofishing effort in each lake with benthic gill netting, as it has been shown to be effective at capturing mobile salmonids in most water depths (Vaux et al. 2000).

We will standardize our electrofishing effort by adopting: a systematic protocol to identify sampling locations; lake surface area as the variable from which effort is calculated; a common electrofishing transect time of 4 minutes (240 seconds); and standardized electrofisher configuration and power output (Appendix A1). We will not however, due to logistical constraints, standardize electrofishing such that each habitat type is sampled proportionally to its relative surface area.

Since electrofishing tends to be size-selective, with larger fish being more vulnerable to capture (reviewed by Reynolds [1996]), smaller fish species and life stages are likely to be underrepresented in our electrofishing catch. Furthermore, large fish are more likely to be seen and counted than small or cryptic species. Small or cryptic fish are only likely to be observed if mobilized toward the anode; however, large fish and their carcasses are typically easier to observe and count, even if they remain beyond the electrical field. Therefore, our results should not be used to infer absolute or relative abundance of fishes.

Multitransect electrofishing will be the principal fish collection method, supplemented in each study lake by benthic gillnetting. Other gear types may also be used if deemed appropriate (e.g., angling, minnow trapping, dip netting). A Smith-Root model GPP 2.5 generator powered electrofisher will be used for all electrofishing transects. The number of transects to be electrofished will be calculated as a function of lake surface area (Appendix A1). The location of transects will be determined on site by the crew leader such that each major nearshore habitat type (i.e., vegetation beds, rocky drop offs, silt flats, inlets, outlets, etc.) is sampled. Additional transects may be sampled at the crew leader's discretion in accordance with project objectives. Each transect will be considered complete upon reaching 4 minutes (240 seconds) of electrofisher on-time. Crews will follow standard electrofishing protocols (Appendix A1) to minimize stress to fish, for operators' safety, and in an attempt to standardize sampling efforts between locations and operators so results are comparable between locations and across time.

Benthic gillnetting will be employed in each lake as a supplementary capture method to better estimate species richness. Many researchers have made recommendations on ways of standardizing gillnetting effort among lakes. For example, Baker et al. (1997) recommend calculating the number of gillnets to be set in a body of water as a function of surface area, as larger lakes are expected to have greater habitat diversity; additionally Bonar et al. (2009) recommend stratifying lakes by bathymetric habitat type (i.e., epilimnetic, mesolimnetic, hypolimnetic) as a relative proportion of surface area and sampling each habitat type proportionally with a minimum of 3 nets per habitat type.

However, due to logistical constraints and the qualitative nature of our main objective, we will not meet these standards. Regardless of lake size or habitat diversity, we will deploy 4 gillnets per lake perpendicular to depth contours in near-shore habitats expected to be occupied by a variety of fish (especially anadromous fish) species/life stages (e.g., inlets, outlets, vegetation margins, abrupt drop-offs). Gillnets will be set prior to electrofishing and retrieved once electrofishing has been completed. For the following reasons we will institute a standard soak time of 4 hours for each gillnet set:

1. to address the need to accomplish all sampling activities for each lake within a single day.
2. the ethical desire to minimize fish and wildlife mortality and bycatch.
3. because Eggleton et. al. (2010) reported finding that fish capture statistics from a 4 hour gillnet set were similar to those of overnight sets.

4. because Minns and Hurley (1988), showed that species accumulation curves for gillnet collections in Lake Ontario begin to flatten out (although do continue to increase) following 3–6 hours of set-time.

All collected fish will be identified to species, and fish fork lengths [measured from tip of snout to fork of tail (or to tip of tail, if no fork)] will be measured to the nearest mm. Field reference books (e.g., Pollard et al. 1997), or copies of appropriate pages from desk references (e.g., Mecklenburg et al. 2002; Morrow 1980) and other materials containing species descriptions, ranges, and identification keys will be available and consulted as necessary. If a species cannot be confidently identified in the field, crews will photograph the specimen, record the observations under a higher taxonomic level (e.g., genus or family name) in the database, and retain a voucher specimen(s) fixed in a 10% formalin solution. Entries for unknown/uncertain species will be annotated in the appropriate comment field with the best guess at identification. At the first opportunity, the voucher specimens and photographs will be examined and identified to species, and the corresponding records in the database updated.

Up to approximately 30 fish of each species and life stage will be measured from each lake—any additional fish captured or seen will be identified and tallied as additional counts. Where more than 30 fish of a given species and life stage are collected, in order to avoid biased sampling of fish to be measured, we will measure every *n*th fish removed from the bucket, where the value of *n* is the estimated number of fish of a given species and life stage collected, divided by 30. For each fish, we will record species (Appendix BS), life stage (Appendix B1), life history (anadromous, resident, unknown), and anomalies in fish appearance or condition (Appendix B2, *sensu* McCormick and Hughes 1998). Where life stage cannot be determined by external features, we will use fork length thresholds identified in Appendix B1 to classify fish into life stage categories. Injuries due to sampling will be noted in the comments field.

Bruising (blackening, usually following the myomeres) may result from electrofishing, and may be accompanied by spinal injury that may not be visible externally. We will minimize frequency (pulses-per-second) and voltage when electrofishing to avoid unnecessary stress and injury to fish. If fish die due to the effects of sampling or processing, we will note the mortality in the comments field.

If spawning by a given species is not directly observed, but the crew leader suspects (based on indirect evidence such as external morphological characteristics, behavior, condition, expression of gametes when handled, or presence of newly emerged young) the species likely spawns within or near the study reach, "suspected spawning" will be recorded in the database for the given species. In addition to recording fish that are collected, we also will record counts (by species and life stage—estimates OK) of additional fish detected, but not collected. We will document any definite barriers to fish passage (Appendix B3).

After being identified, measured, and allowed a period of recuperation, all fish (except specimens to be retained for further study) will be released. Specimens to be retained include:

- Those needed to confirm species identification.
- Up to 12 large (> 300 mm) individuals of each of the following optionally-anadromous fishes will be retained (whole, frozen) from each study site where they are collected for an otolith-chemistry study for evidence of anadromy: Dolly Varden; humpback whitefish; and Bering cisco. These retained specimens will be killed by a blow to the head or an overdose of CO_2 and retained (frozen) for further study to detect evidence of anadromy using otolith trace elements to indicate periods of saltwater residency. In the

lab following fieldwork, we will extract the pair of sagittal otoliths and record standard meristic data from each retained fish.

- On behalf of Andres Lopez (Curator of Fishes, University of Alaska Museum, Fairbanks), we will retain (in 10% formalin solution) up to 10 (from the entire study area or each major drainage) voucher specimens (<300 mm-long specimens only) representing each fish species collected. Before storing these specimens in formalin, we will take from each specimen a right-side pectoral fin clip and store it in a uniquely-numbered vial with 95% ethanol—one clip per vial. We will label each whole retained specimen with a pre-numbered tag attached to the right operculum with a zip tie. Each individual fin clip retained for this task will be placed in a separate pre-numbered vial. Tag numbers and vial numbers will be recorded on a datasheet for each individual fish. For specimens >200 mm, we will make an incision through the belly wall before placing in formalin. In addition, we will collect up to a total of 40 fin clips from Pike, Alaska blackfish, Arctic lamprey, grayling and least cisco.
- On behalf of Michael Young (Research Fisheries Biologist with the U.S. Forest Service), we will collect sculpin fin clips to support a regional sculpin genetic study. We will collect a pelvic fin clip from each sculpin captured. Fin clips will be preserved using chromatography paper and we will record the Station ID of the lake.

See Table 2 for a list of recorded variables associated with fish-collection events and fish catch that will be recorded at each study site.

Fish-collection protocols for lakes

See Appendix A1 for detailed step-by-step lake-team fish collection protocols.

Electrofishing

After arriving at the study location, the lake team will calculate the number of transects to be electrofished based on the lake surface area value taken from the NHD (Appendix C). Each transect and its associated variables and findings will be recorded in the database separately as unique sample events.

The lake team will use an inflatable boat (Grabner Ranger) measuring 13-ft long, with a load capacity of 750 pounds and with a custom made aluminum rowing frame equipped to accommodate (from stern toward bow): an electric motor, a Smith-Root GPP 2.5 electrofisher generator and control box; a tractor seat for the captain; a live box (cooler); and a lean bar in the bow (see Figure 3).

The following electrofishing system will be set up on the inflatable boat: a Smith-Root GPP 2.5 generator-powered electrofisher and control box; an anode system comprised of 2 Smith-Root SAA-6 adjustable spider-array electrodes, each having 6 stainless steel dropper cables (38-in long, 3/16-in diameter), suspended from booms [Smith-Root light-duty fiberglass booms (p/n 06248) or modified 12-ft fiberglass pole vault poles] extending out over the bow; and a cathode system comprised of 4 sections of angle iron suspended into the water along both sides of the boat each with a series of 6 dropper cables (similar to those in the anode system). While electrofishing the driver will maneuver the boat along the predetermined transect, and a second crewmember will stand on the forward platform and control the electrofisher foot switch while collecting fish with a fiberglass handled dip net.

The GPP 2.5 cannot produce smooth DC, so a pulsed-DC waveform will be selected. By default, the lake team will begin electrofishing using a pulse frequency of 30 pps. To avoid exposing fish to more harmful higher pulse frequencies, 60 pps may only be selected in circumstances where target species are unable to be consistently brought to a capture prone response (ideally taxis) following experimentation with other output settings (outlined in Appendix A1) while using 30 pps. Pulse frequency may at no time exceed 60 pps. At the end of the transect, fish will be processed according to the protocol detailed in Appendix A, and electrofisher settings and fish observations will be recorded in the database.

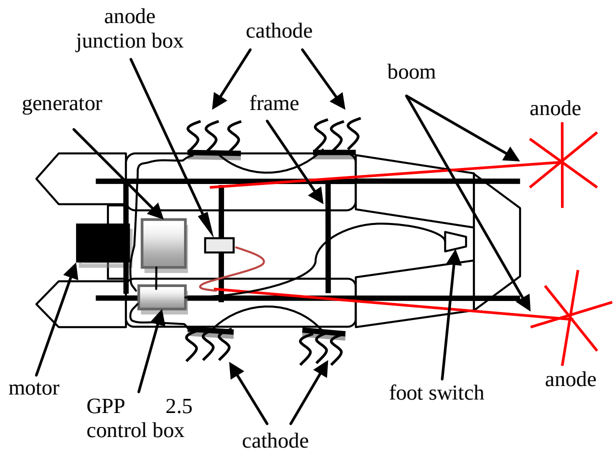

Figure 3.–Inflatable lake sampling boat schematic.

Gillnetting

Prior to electrofishing, using best professional judgment, the lake team will select each benthic gillnet location such that habitat features expected to be of elevated importance to anadromous species (near shore rearing habitats, migration corridors [i.e., inlets, outlets, etc.], spawning habitats, etc.) of various life stages are represented. Gillnets will be set following the procedure described by Bonar et al. (1996) for deploying gillnets in small standing waters (Appendix A1). Each set and its associated variables and findings will be recorded in the database separately as unique sample events.

Variable-mesh monofilament gillnets measuring 24.8 m (80 ft) long by 1.8 m (6 ft) tall containing 8 mesh panels ranging from 19–64mm (.75–2.5 in.) (bar mesh) will be used (with the following modifications) as this configuration has been adopted as a standard for all systems where benthic gillnetting is used to capture salmonids ranging in size from 190-650mm total length (Bonar et al. 2009). Given the expected presence and relative importance of juvenile salmonids (60–120 mm), 2 additional 13 mm (.5 in.) bar-mesh panels have been appended (one on each end) to this standardized net such that these individuals are more effectively targeted. One crewmember will operate the motor and guide the boat (in reverse) along the predetermined set path (perpendicular to depth contours, beginning near shore), while the other crewmember plays out the gillnet ensuring that it is free of twists and comes to rest securely in the intended location. Following deployment of all nets, the crew will complete all remaining sampling tasks prior to retrieving the nets in the order in which they were deployed. All gillnet captured fish will be processed, according to the protocol detailed in Appendix A4. Each net will be processed prior to retrieval of subsequent nets.

In lakes that are determined (following the protocol outlined in the *aquatic and riparian habitat assessment* section of this report) to be thermally stratified (typically large, deep lakes), the crew leader may determine that the deployment of a pelagic gillnet in the vicinity of the thermocline would be advisable to most fully document species presence. In such cases, one of the benthic gillnets may be modified and used for this purpose.

AQUATIC AND RIPARIAN HABITAT ASSESSMENT

At each lake site where fish collection is attempted, we will also measure a standard suite of habitat variables describing water quality, lake morphology, both aquatic and riparian vegetation distribution, and substrate. See Table 2 for a list of habitat variables, along with information about instruments used, units and domains, and precision of measures.

Bathymetric site

We will establish a bathymetric sample site in the general vicinity of the point of maximum depth (i.e., over the main lake basin away from littoral zones). The approximate location of this site will be observed and documented during a low level fly over of the lake prior to landing.

Most habitat variables will be measured as point samples at the bathymetric sample site; however, some variables (i.e., lake morphology, substrate composition and both aquatic and riparian vegetation distribution) will be assessed for the lake as a whole.

Site photos

For each station recorded in the database, we will take ground level and aerial photographs with a digital camera. After marking the Station GPS waypoint, the first photo taken at each station will be of the GPS screen showing the GPS date and time. This will provide the information needed to accurately associate photos with the correct Station and also to geotag each photo with GPS data. We will take several additional photos at each site, including a photo of the YSI 556 screen, photos of the fish collection sites, as well as a sufficient number of aerial photos to accurately portray the overall characteristics of the study lake. Additional photographs should be taken of notable habitat features, fish, or other subjects of interest. After returning to the office, we will link photos with Sites and use GIS to derive the elevation of each site from the National Elevation Dataset digital elevation model, along with other attributes (legal description of Site locations, USGS quad name, HUC) to be reported.

Water quality

We will measure four water quality variables (temperature, pH, dissolved oxygen [DO], conductivity) with a YSI 556 multiprobe meter with a built-in barometer (used in calibrating dissolved oxygen). The pH, dissolved oxygen, and conductivity sensors will be calibrated[2] biweekly (or more frequently if readings are suspect). To measure these variables, we will place the probe at 0.5 meters of depth, and wait for the readings to stabilize before recording them.

In lakes that are expected to be thermally stratified (typically large and/or deep lakes), additional temperature and DO measurements may (if time allows) be taken to confirm this and locate the thermocline(s). To do this, the crew will take a second temperature measurement near the bottom (or at the extent of the probe cable in deep lakes) to confirm temperature stratification

[2] The pH sensor will be calibrated with pH 4, 7, and 10 standards. The dissolved-oxygen sensor will be calibrated in water-saturated air. The conductivity sensor will be calibrated with a 1 mS/cm conductivity standard.

before taking temperature readings every 2–5 meters along a vertical profile through the water column until the approximate depth of the thermocline(s) is identified.

We will measure water transparency using a Secchi disk following the methods of McMahon et al. (1996). First we will record the disappearance depth of the Secchi disk as it is lowered into the water column. Then we will record the depth of reappearance of the Secchi disk as it is raised. We will record the transparency as the average of these 2 depths. We will also visually assess water color (Appendix B4).

Lake morphology

For each lake, the following variables will be collected to characterize its morphology and classify its ecological setting such that relationships between fish distribution and these variables can be later examined: Lake origin; lake type; surface area (sq. km); perimeter (km); shoreline development; and substrate composition.

Lake origin and *Lake type* (*sensu* Milner et al. 1997, see Appendix B8) will be classified for each sampled lake following the field season based upon field observations of each lake and its surrounding landscape characteristics and post field season GIS based site inspections.

The field crew will make an initial classification of each lake in the field based upon aerial and ground based observations of lake morphometry (i.e., shape, depth, etc.) and the surrounding ecological and geological features that shape the landscape (i.e., evidence of glaciation, fluvial processes, etc.). Following fieldwork, using various GIS based applications, the field classification of each lake will be assessed by a thorough examination of the lake and its surroundings. Using both field observations and GIS inspections, the final lake origin classification will be assigned to each sample lake.

Surface area and *perimeter* will be taken directly from the NHD, prior to fieldwork, and later used to calculate *shoreline development* following the methods of Mackie (2001).

To characterize *substrate composition*, we will visually assess the relative dominance of the 3 most prevalent nearshore substrate classes (Appendix B4) along the perimeter of the lake. This determination will be made based upon site observations made throughout the visit.

Aquatic vegetation

We will estimate the relative dominance of nearshore aquatic vegetation communities from both aerial and ground based observations. These observations will be very general in nature; no effort will be made to distinguish species composition, but rather simply classify the relative dominance (primary, secondary and tertiary) of the following vegetation classes: unvegetated; submergent vegetation; emergent vegetation.

Riparian vegetation

From both aerial and ground based observations we will estimate the 3 most dominant riparian vegetation communities (sensu Viereck et al. 1992; Appendix B6) around the periphery of the lake (between 0 and 30 meters) and measure its canopy height and identify any disturbance (Appendix B7). We will estimate canopy heights <1.5 m with a graduated rod, and canopy heights >1.5 m with a clinometer and range finder[3].

[3] Canopy height can be estimated by: 1) multiplying the horizontal distance (*d*) to a representative tree (measured with a range finder) by the angle (%; measured with a clinometer) from eye level to the top of the tree, 2) multiplying the angle (%) from eye level to the base of the tree by *d*, then 3) taking the sum of the 2 heights (eye level to tree top + base of tree to eye level).

PERMISSION FOR ACCESS TO STUDY SITES

ADF&G is responsible for the sustainability of all fish and wildlife throughout Alaska, regardless of land ownership. No prior permission is needed for ADF&G to access study sites located on State of Alaska (54% of the 4-year study area and 68% of the 2014 study area; see Table 1) or BLM (9% of the 4-year study area and 11% of 2014 study area) lands. A Master Memoranda of Understanding (MOUs) between ADF&G and BLM recognizes the right of ADF&G to enter onto their lands at any time to conduct routine management activities. Under the MOUs, ADF&G informs BLM of the project and estimated dates but does not need formal permission for these activities. On other lands however (e.g., private, native, municipal, Department of Defense), prior permission is needed to access study sites where public access is not available. To identify any study sites where prior approval may be needed for access, target-lake locations were plotted on a land status map in GIS (Appendix D). From inspection of this maps it was determined that for 2014, there are target lakes located on: Bristol Bay Native Corporation lands, Portage Creek Village lands, Twin Hills Village Lands and Koliganek Village Lands. Prior to visiting these sites, we will apply for permission to access them. We will not access any sites above the OHW level without prior permission from the land owner.

Table 1.–General land status within 4-year and 2014 study areas.

Land ownership	4-Year study area		2014 study area	
	sq km	%	sq km	%
State	53,211	54	24,157	68
Native Corp.	23,020	24	6,282	18
BLM	9,213	9	4,016	11
USFWS	2,950	3	475	1
USFS	4,037	4	0	0
Municipal	1,656	2	179	<1
Private	2,560	3	5	<1
Native Allotments	676	1	319	1
DOD	209	<1	1.5	<1
Total	97,530	100	35,436	100

Source: Alaska Department of Natural Resources, Land Records Information Section. Alaska General Land Status GIS layer. Published October, 2013. Available online at: http://www.asgdc.state.ak.us/,

Table 2.–List of variables to be collected during fieldwork.

Variable name	Equipment	Units/Domain	Precision	Comment
Geographic information				
Project Code & Station ID	-	text	-	5-digit alphanumeric—see Stations, Waypoints, and Visits heading in text.
Station location	consumer-grade GPS unit (e.g. Garmin GPSmap 60CSx or 76S)	decimal degrees (WGS84 datum): latitude (DD.DDDDD); longitude (-DDD.DDDDD)	0.00001 degrees	Habitat station located over lake basin
Geodetic datum		Text	-	Default is WGS84.
Water-body name	Water-body name from USGS topo map	text	-	
Geographic comments	-	text	-	Describes location of study site in relation to adjacent long-term or permanent geographic features
Visit information				
Observers	-	list of field staff	-	
Date/time	field notebook computer	mm/dd/yyyy hh:mm:ss	1 s	Value input automatically from computer's clock when data entry is begun
Camera counter	-	sequential integers	-	List of photo filenames (last 3 digits only) associated with each station
Visit comments	-	text	-	Physical and biological conditions at the station during the visit—focus on ephemeral conditions, such as weather or stream conditions, or the dynamics of riparian conditions, that may help explain other recorded observations
Wildlife comments	-	text	-	Anecdotal wildlife observations, particularly those that relate to fish.
Water quality				
Water temperature	YSI 556 meter	°C	0.01 °C	Sample at 0.5 m depth; If stratified, the thermocline may also be located and its temperature measured.
pH		pH units	0.01 pH units	Sample at 0.5 m depth
Dissolved oxygen		mg/L	0.01 mg/L	Sample at 0.5 m depth
Conductivity		µS/cm	1 µS/cm	Ambient conductivity (not temperature corrected). Sample at 0.5 m depth
Water clarity	Secchi disc	Average of disappearance and reappearance depths (m)		Record disappearance and reappearance depths, the average will be a calculated field.
Water color		see Appendix B4	-	

-continued-

Table 2.–Page 2 of 4.

Variable name	Equipment	Units/Domain	Precision	Comment
Lake morphology				
Lake origin	-	see Appendix B8.–Lake origin and lake type classes (Milner et al. 1997).		Initial classification to be made in the field based upon site observations. Classification will be refined back in the office using GIS based applications.
Lake type		see Appendix B8.–Lake origin and lake type classes (Milner et al. 1997).	-	Same as above.
Surface area	-	sq. km	-	Value will be recorded from NHD information.
Perimeter	-	km	-	Value will be recorded from NHD information.
Shoreline developement	-	index value (1–*n*)	-	Equation: SLD = S/(2*SQRT(Aπ)), where S=length of shoreline and A=area of lake.
Substrate composition	-	see Appendix B4	-	3 most dominant substrate classes for the lake as a whole within near-shore habitat.
Aquatic vegetation communities				
Aquatic vegetation composition	-	submergent vegetation, emergent vegetation, unvegetated	-	Estimated for the lake as a whole; record primary, secondary, and tertiary dominance within the lake margin.
Riparian vegetation communities				
Riparian vegetation composition	-	forest, scrub, herbaceous, unvegetated	-	Estimate (primary, secondary and tertiary dominance) for lake as a whole from 0-30 m from bank.
Canopy height	graduated rod (< 1.5 m); clinometer & range finder (> 1.5 m)	m	0.1 m (< 1.5 m); 0.5 m (>1.5 m)	
Disturbance	-	Disturbance classes (Appendix B7)	-	

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Table 2.–Page 3 of 4.

Variable name	Equipment	Units/Domain	Precision	Comment
Fish-collection events				
Event location	-	lake, slough, beaver pond, wetlands, connected pond	-	general location description of fish-collection event.
Macro habitat		Littoral, limnetic-pelagic, limnetic-benthic		
Micro habitat		Inlet, outlet, emergent veg. margin, submergent veg. bed, silt flat, drop-off, near-shore, off-shore		
Sample site coordinates	consumer-grade GPS unit (e.g. Garmin GPSmap 60CSx or 76S)	decimal degrees (WGS84 datum): latitude (DD.DDDDD); longitude (-DDD.DDDDD)		Save waypoint at beginning and end of each electrofihed transect and at the beginning of each gillnet set.
Sample times	field notebook computer	mm/dd/yyyy hh:mm:ss	1 s	Record set and pull time (gillnetting), and start and stop time (e-fished transects).
Fish-collection method	-	backpack electrofisher, boat electrofisher, gillnet, seine, visual observations (ground, boat, or air), dipnet, angling, none	-	
Waveform	electrofisher setting	DC-pulsed; DC-unpulsed	-	
Range		Low or High	-	(GPP 2.5 only)
Percent of range		0–100 %	Continuous	(GPP 2.5 only)
Frequency		pulses per second (pps)	1 pps	
Current	electrofisher output meter	A	0.01 A (LR-24); 0.1 A (GPP 2.5)	Peak current (LR-24); average current (GPP 2.5)
Electrofisher on-time	electrofisher timer	s	1 s	
Efficiency	-	excellent, good, fair, poor	-	Perceived electrofishing efficiency, relative to optimal conditions.
Catch				
Reach length	GPS (trip computer mode, or track)	m	1 m	Indicate actual length of fish-collection reach, measured by GPS.
Species	-	list of Alaskan freshwater fish species	-	
Life stage	-	see Appendix B1	-	

-continued-

Table 2.–Page 4 of 4.

Variable name	Equipment	Units/Domain	Precision	Comment
Catch contd.				
Life history	-	anadromous, freshwater-resident, marine, unknown, N/A	-	
Suspect spawning	-	yes, no	-	
Barrier	-	see Appendix B3	-	
Fork length	fish measuring board	mm	1 mm	
Sex	-	male, female, blank (if sex was not determined)	-	
Anomalies	-	see Appendix B2	-	
Retained	-	Check box (Y/N)	-	Indicate each individual fish retained.
Tag No.	-	10-digit alphanumeric text	-	For retained specimens, indicate the tag number affixed to each fish.
Vial No.	-	10-digit alphanumeric text	-	Record of tissue sample was taken.
Photo No.	Digital camera	3-digit positive integer	1	For each fish photographed, indicate the photo number (last 3 digits of the photo filename). May use comma or hyphen to separate non-sequential photo numbers or indicate a range of photo numbers.
Individual fish comments	-	text		Comments pertaining to an individual fish (e.g., sampling injuries or mortalities, unusual features or behavior)
Additional counts estimated	-	Integer—no. of fish	1 fish	
Estimated	-	yes, no	-	Indicates whether the no. of additional fish recorded above was an estimate or a direct count
Species-life-stage comments	-	text	-	Comments pertaining to an entire group of fish of the same species and life stage

DATA COLLECTION AND REDUCTION

Other than derived values to be computed later, we will directly enter all measured or observed values in the field (while at the station) into a Microsoft Access relational database (MDB) using a ruggedized notebook computer (Itronix GO Book Max, Itronix GO Book III, or xPlore iX104C4). Wherever appropriate, the MDB will use drop down lists or validation rules (e.g., for continuous data within an acceptable range of values, such as pH values restricted to 0–14).

In base camp, at the end of each field day, crew leaders will error check all data recorded that day. Each team's MDB file, GPS unit files (waypoints and tracks), and digital photographs will be backed up each day onto an external hard drive and then transferred to a laptop computer, which will be securely stored and transported separately from the field computers.

After the field season, the MDB will be checked for nonsensical values. Using ESRI ArcGIS software and GIS layers, we will derive additional station location information (i.e., USGS quadrangle name, HUC, meridian, township, range, section, AWC Region, NED elevation) for each station. We will also update fish life stage assignments based on Appendix B1. These values will then be appended into the MDB.

Data from the MDB will then be replicated to the AFFI database (AFFID), a Microsoft SQL Server database, for long term usage. Accessing AFFID data for staff review, editing, and reporting is primarily achieved through a Microsoft Access Data Project (ADP). SQL Server is also used to provide raw data and web based reports for the Internet using ESRI ArcIMS, Adobe ColdFusion, and related GIS applications, along with other appropriate and available map layers (e.g., topographic maps, hydrography, land ownership coverage).

DATA ANALYSIS

For each water body where we observe anadromous fish, we will prepare and submit a nomination package to the AWC. The nomination package will include all the information required by the AWC program (see Appendix H1for an example) and will include a summary of all fish species observed (anadromous or not), from every sampling event on that water body (regardless if anadromous fish were observed during each sampling event).

SCHEDULES AND REPORTS

SAMPLING DATES

See Table 3 (schedule of project activities) and Table 4 (field-crew schedule) below:

Table 3.–Schedule of project activities.

Year	Dates	Activity
2014	July 1	Complete operational plan.
	July 11	Shotgun and bear-safety training.
	July 28	Deploy full crew to Alagnak Lodge; set up day; helicopters arriving.
	July 29	Day 1 of sampling Alagnak Lodge area.
	August 8	Full crew moves to Dillingham base camp.
	August 19	All teams return home.
	August 25	Begin data reduction and validation.
	September 30	Submit AWC nominations.
	November 30	Post data summaries online.
	December	Analyze sampling-sufficiency data.
	October–December	Extract otoliths from retained specimens.
2015	January–March	Otolith chemistry analysis.
	April 30	Draft FDS report submitted to Regional Supervisor.

Table 4.–Field-crew schedule, including the associated stream sampling teams.

	Cataraft Team	
Team	Alagnak Lodge (July 28–August 8)	Dillingham (Aug 8–19)
A (Mainstem and Intermediate streams)	James Bales	Joe Giefer
	Ryan Snow	Bob Powers

	Lake Team	
Team	Alagnak Lodge (July 28–August 8)	Dillingham (Aug 8–19)
B (Lakes)	Joe Giefer	James Bales
	Holly Zafian	Josh Brekken

	Headwater Team	
Team	Alagnak Lodge (July 28–August 8)	Dillingham (Aug 8–19)
C (Headwaters streams)	Raye Ann Neustel	Raye Ann Neustel
	Joe Buckwalter	Marla Carter

RESPONSIBILITIES

Table 5.–List of personnel and duties.

Name	Duties
James Bales	Principle investigator, field-crew supervisor, Team-A and -B leader. Prepare and manage project budget and funding proposals. Prepare operational plan. During fieldwork, perform daily data quality-control procedures and data backups. Complete post-season data reduction, review, and analysis. (Co)author publications, reports, and papers for scientific journals.
Josh Brekken	Team-B member
Joe Buckwalter	Team-C member.
Marla Carter	Team-C member.
Adam Craig	Provide guidance on inventory design. Assist with post-season data analysis. Review project operational plan and reports. (Co)author on papers for scientific journals.
Joe Giefer	Team-A and -B leader. Prepare operational plan. During fieldwork, perform daily data quality-control procedures and data backups. Complete post-season data reduction, review, and analysis. Prepare and submit nominations of appropriate waters to the AWC. Conduct specimen dissections and otolith extractions. (Co)author publications, reports and papers for scientific journals.
Jason Graham	Prepare land-status maps with target streams.
Raye Ann Neustel	Team-C leader. Assist with all aspects of project. Coordinate fieldwork logistics. Coordinate field crew trainings. Inventory, procure, maintain, and package field equipment and supplies. Prepare and submit nominations of appropriate waters to the AWC. Conduct specimen dissections and otolith extractions.
Bob Powers	Team-A member
Skip Repetto	GIS analyses of target stream locations. Post summarized results to project web site. Maintain and develop online mapper.
Thalassa Smith	Prepare field maps and maps for FDS report.
Ryan Snow	Team-A member. Design project database. Compile field data files in Anchorage network. Assist data retrieval and database reporting. Provide technical support for software and hardware development operations and maintenance. Develop software tools to integrate GIS and database functions. Develop software tools to display spatial, tabular, and graphic data via the Web.
Holly Zafian	Team-B member.

BUDGET

Table 6.–Budget summary.

Cost category	Allocation ($K)
100 Personnel	293.4
200 Travel	8.9
300 Contractual	171.7
400 Supplies	29.5
500 Equipment	0.0
Total	503.5

Table 7.–Summary of personnel expenses.

Name	PCN	Job class	Months	OT (hr)	Haz (hr)	Salary & benefits
James Bales	11-4153	Habitat Biologist III	12.0	0	175	104.7
Joe Giefer	11-6140	Habitat Biologist II	12.0	0	150	104.4
Ryan Snow	11-6087	Analyst/Programmer IV	1.0	0	0	10.3
Vacant	11-6118	GIS Analyst II	1.0	0	0	10.2
Raye Ann Neustel	11-4335	F&W Tech III	7.0	100	200	44.5
Vacant	11-L403	Habitat Biologist II	1.0	0	200	6.9
Vacant	11-L405	Habitat Biologist IV	1.2	0	200	12.4
Total						293.4

Note: The budget allocations presented in these tables are not intended to represent expenses relating only to this lake-fish sampling project, rather they represent expenditures associated with all AFFI activities.

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APPENDIX A. FIELD PROTOCOLS

Appendix A1.–Fish sampling protocol for lake teams.

The objective is to detect all the common fish species found in the lake, with emphasis on anadromous fishes. The chronologic procedure for sampling each lake is presented below. Prior to preparing for fish sampling, a bathymetric sample site must be selected in the vicinity of the point of maximum depth as determined by aerial reconnaissance. At this site, the first GPS waypoint will be saved prior to habitat characterization and data entry which is to follow the procedure described under the aquatic and riparian habitat assessment section of this document.

Procedures to collect fish by benthic gillnetting

Onshore at study site

1. Prepare the gillnet and make sure it is free of tangles and debris and that it is neatly stowed in a tub.
2. Load and secure all needed equipment before departing from shore.
3. Make note of the location of all safety equipment.
4. Put on a life jacket and wear polarized sunglasses to aid vision.

At each set site

1. Determine the location of each set site (preferably 4) based on best professional judgment such that project objectives are expected to be most efficiently met. Gillnet sites should be selected such that habitat features expected to be of elevated importance to anadromous species (near shore rearing habitats, migration corridors [i.e., inlets, outlets, etc.], spawning habitats, etc.) of various life stages are represented.
2. Check the set site for any obstacles that could endanger the crew or damage the net during deployment and recovery.
3. Important! Check the depth at the set site to make sure the buoy lines on the net are long enough so that the net doesn't sink beyond reach.
4. Save a GPS waypoint at the set site.
5. Play out the net perpendicular to the depth contours of the lake (or perpendicular to shore if contours are not apparent) by first dropping one weighted end (starting with the near shore end) overboard and backing up until the entire net is taut and securely anchored to the bottom forming an upright fence of netting.
6. Record the time at which the net is set and proceed to the next set site. Following the same protocol, continue setting nets until the last net is out.
7. Shift to electrofishing (described below) while the gillnets soak.
8. Following the minimum 4-hour set-time (after all electrofishing has been completed), each net should be pulled and its catch processed in the order in which they were set.
9. With the boat oriented into the wind, the net-person will free each fish and deposit them into the live well while neatly stowing the net back into its container; meanwhile the captain slowly moves the boat along the set (if conditions require) at a pace determined by the net-person.
10. Fish observations will be recorded at each set and entered into the database as unique sample events in accordance with Appendix 4.

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Procedures to collect fish by boat electrofishing in lakes (adapted from McCormick and Hughes 2000)

Onshore at launch site

1. Check generator oil and fill tank with gas (wipe up any spillage).
2. Attach electrodes to boat, and connect their cables to the corresponding outlet on the control box. If the fishing site is distant, keep electrodes and anode poles in boat.
3. Connect generator and pulsator (control box).
4. Confirm that all gear for the day is in the boat.
5. Put on a life jacket. Wear polarized sunglasses to aid vision.

At sample site

1. Check surface area of lake (pre-determined from NHD; Appendix C); this will be used along with the below table to calculate the number of transects to electrofish (Baker et al., 1997). The standard transect length will be 4 minutes of on-time (displayed, in seconds, on the electrofisher control box). Record fish observations and electrofisher settings separately for each transect under a unique sampling-event set code.

Lake area (sqkm)	Number of transects
.01-.04	2
.05-.14	3
.15-.29	4
.30-.74	5
.75-1.49	6
1.50-2.49	7
2.50-5.99	8

2. Check all electrical connections and suspend the electrodes in the water. The wetted surface area of the cathode(s) should be greater than that of the anode(s). Fill live well and put on electrically-insulated gloves. Verify that all electrical switches are off, that all non-target organisms are clear of the water or 2 boat lengths away, and that both crewmembers are clear of the water and electrodes and ready to begin electrofishing. Reset the timer on the electrofisher control box to zero at the start of each transect.
3. If ambient conductivity is <300 µS/cm, set the Range dial to High. If ambient conductivity is >300 µS/cm, set the Range dial to Low. Switch the Mode dial to DC (**Caution! The position of this switch should not be changed when the foot switch is engaged!**) and select an initial frequency of 30 pulses-per-second (pps) and an initial Percent of Range (POR) setting of 10%.

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4. Start the generator and depress the foot pedal to begin electrofishing. Increase POR as needed to elicit a capture-prone response [i.e, taxis (induced movement of the fish toward the anode) or forced swimming] from fish, while minimizing responses associated with elevated trauma (i.e., immobilization, branding, spinal deformities, or recovery period exceeding 15 seconds).

   Note: Where water conductivity is high (>300 µS/cm), avoid using POR settings in excess of 60%, which will simply increase duty cycle, but not peak voltage, and may overload the generator (Martinez and Kolz 2009). If the generator sounds labored, decrease POR and/or switch from High to Low range.

5. If fish taxis cannot be achieved, increase frequency to 60 pps, return the POR dial to 10%, and repeat Step 5.

6. Select transect locations based on best professional judgment in accordance with the objectives of the project. Each major near-shore habitat type (i.e., vegetation beds, rocky drop-offs, inlets, outlets, etc.) should receive effort. During electrofishing, use electric motor to maneuver along the predetermined transect while avoiding any obstacles and positioning the anode(s) into habitats providing cover for fish. To the degree possible, proceed in a straight line along the transect, though deviating slightly to include important microhabitats (e.g., large substrate elements, large wood, debris piles, undercut banks, aquatic macrophyte beds, overhanging vegetation), Most effort should occur at depths less than 3 m wherever possible.

7. When approaching microhabitats: maneuver the boat, with electrical current off, so the anode(s) approach near to fish-cover elements then begin electrofishing as the boat is backed away from the cover. Electrofish intermittently to avoid herding fish. After electrofishing continuously for a duration of up to 10 s, proceed quietly for 5–10 m before resuming electrofishing. Do not place the boat or crew in danger in order to fish particular habitats.

8. The netter uses a dip net with non-conductive (e.g. fiberglass) handle to retrieve fish, which are then deposited into a livewell for later processing. Try to capture fish before they approach near to the electrodes, and remove fish quickly from the electric field. Try to net all fish seen. When this is not feasible (e.g., in highly-productive systems), try to collect a representative sample of the fish assemblage (e.g., not just large game fish). Pay special attention to netting small and benthic fish, as well as fish that respond differently to the electric field—not just the big fish that move to the surface. If benthic fish are being missed, hold the net behind the anode just above the bottom so some are collected.

9. Change the water in the livewell periodically to minimize stress prior to processing. If fish in the live well begin to show signs of excessive stress (e.g., loss of righting response, gaping, gulping air, excessive mucus), stop electrofishing, anchor or land the boat on shore, and process them. This should only be necessary on very warm days, or if very large numbers of fish are collected. Electrofishing may also need to cease at times to immediately process and release large fish. If fish are processed and released prior to the end of a transect be sure to release them behind the boat, to reduce the likelihood of recapturing them.

10. Using a GPS unit, save a waypoint at both the beginning and end of each transect. At the end of each transect, process the fish according to Appendix A2.

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11. Record in the database the final, or most successful, electrofisher output settings (mode, range, POR, pulse frequency, current, electrofisher on-time, and duty cycle and power, if known), sampling efficiency (poor, fair, good, excellent), and distance sampled, along with fish observations, including fish collected while electrofishing, as well as any additional fish observed within the transect, but not collected[1]. If conditions prevent safe or effective electrofishing within a transect, the conditions, and their effect on sampling efficiency, should be noted in the Sampling Event tab in the database, and the length of transect that was actually sampled should be noted.

12. Additional transects may be electrofished based upon best professional judgment to include other important under-represented habitats.

13. Be sure the station visit information is completely entered/recorded before leaving the site.

[1] In the database, only those fish captured while electrofishing should be associated with an electrofishing sampling event. Fish observed, but not captured should be recorded under a separate sampling event (e.g., Visual observations-boat). Fish collected from off-channel habitats (e.g., tributaries, side channels, floodplain habitats, adjacent beaver ponds) should be recorded under a distinct sampling event.

Appendix A2.–Procedure to process collected fish.

1. Anesthetize collected fish with AQUI-S 20E according to instructions.
2. Remove 1 fish at a time from the sedation bucket and place on a length-measuring tube (FL ≤ 250 mm) or board (FL ≥ 250 mm).
3. Identify all collected fish to species (Appendix B5), life stage (Appendix B1), and life history (anadromous, resident, marine/estuarine, unknown) and measure fork length to the nearest mm. Refer primarily to Pollard et al. (1997) to identify unknown salmoninae (salmon, trout, or char) and to Mecklenburg et al. (2002) for all other species. Also refer to photos of known specimens for confirmation. Check each fish for external anomalies (Appendix B2). Document any definite fish passage barriers (Appendix B3) found in or adjacent to the reach. Immediately after identification and measurement, place fish in a second bucket of fresh stream water for recovery.
4. Take a representative photo of each anadromous species and life stage, as well as of any rare or unusual fish, fish with anomalies, or fish where ID was uncertain. Record the photo number(s) associated with each fish in the database.
5. Take a fin clip from each Dolly Varden to be retained (see below), from additional species requested by UAF, and from sculpin requested by U.S. Forest Service. Follow the appropriate instructions for taking fin clips (UAF instructions all species, U.S. Forest Service instructions for sculpin). Record the fin clip vial number in the database.
6. Retain the following specimens:
   - <u>Species unknown</u>: In 10% formalin—up to 5 (from each site) individual fish of each species and life stage that cannot be confidently identified in the field;
   - <u>UAF Museum</u>: In 10% formalin—voucher specimens of each species (see UAF instructions);
   - <u>Optionally-anadromous fishes for otolith study</u>: Frozen—up to 12 large (> 300 mm, individuals from each study site where they are collected of each optionally-anadromous species, such as: Dolly Varden; humpback whitefish; least cisco, and Bering cisco.
   - <u>ADEC Veterinarian</u>: Frozen—up to 6 individual resident fish from each study site where they are collected (See DEC instructions).

   Euthanize (by a blow to the head, or using AQUIS-20E) all specimens to be retained. Tag any retained fish with a unique tag number, and record the tag number in the database. For UAF, each fish must be individually tagged. For all other retained specimens, fish of the same species and life stage that were all collected from the same reach may be retained as agroup with a single unique tag for the group. Any specimens retained for the otolith study must be frozen. All other specimens should be stored in 10% formalin solution. For specimens >200 mm, make an incision through the belly wall before placing in formalin. Keep specimens cool (e.g., in fresh stream water) until they can be put in formalin or frozen. ***CAUTION! MINIMIZE THE CHANCE OF ATTRACTING WILDLIFE BY KEEPING RETAINED FISH INSIDE A COVERED COOLER OR HEAVY DUTY PLASTIC BAG. NEVER LEAVE SPECIMENS UNATTENDED IN THE FIELD.***

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7. While 1 crewmember processes fish, the other will enter fish observations into the appropriate fields in the database.
8. Release fish to still water in the fish collection reach. If additional contiguous fish collection will be conducted, release fish behind the boat to reduce the likelihood of their recapture.
9. Record the species, life stage, life history, and count, along with any comments indicating average size, behavior, anomalies, etc., of any additional fish that were observed, but not collected (e.g., visually-observed adults).

APPENDIX B. LOOKUP TABLES

Appendix B1.–Fish life-stage classes and threshold fork-length values.

Descriptions of fish life-stage classes.

Code	Name	Description
FXE	fixed egg	Eggs adhering to or buried within a substrate.
PLE	planktonic egg	Non-adherent, buoyant or nearly so, eggs drifting with currents.
FXA	alevin	Pre-emergent sac-fry within the interstices of the substrate.
PLL	planktonic larvae	Hatched juveniles drifting with currents and with no, or poorly, developed volitional swimming capabilities.
JUV	juvenile	Sexually immature free-swimming fish.
SMT	smolt	Juvenile anadromous fish on first emigration from fresh to marine water.
JOA	juvenile/adult	Free swimming fish whose sexual maturity is not determined.
ADT	adult	Fish at, or approaching sexual maturity.
ASP	adult spawning	Adults observed in the act of spawning.
KLT	kelt	Post-spawning iteroparous anadromous fish in freshwater prior to return to marine water.
CAR	carcass	Post-spawning adult carcass.
NAP	not applicable	No fish observed or general information record only.
NRD	not recorded	Life stage not recorded.

Fork-length threshold values (mm) used to assign fish to selected life-stage classes.

	Life stage		
Species	Juvenile	Juvenile-or-adult	Adult
lamprey-unspecified	-	-	-
longnose sucker	<188	188–348	>348
northern pike	<330	330–448	>448
Alaska blackfish	<42	42–113	>113
broad whitefish	<343	343–448	>448
humpback whitefish	<280	280–363	>363
least cisco	<199	199–318	>318
round whitefish	<199	199–318	>318
inconnu (sheefish)	<586	586–648	>648
Arctic grayling	<190	190–328	>328
pink salmon	-	-	-
chum salmon	-	-	-
coho salmon	-	-	-
sockeye salmon	-	-	-
Chinook salmon	-	-	-
Dolly Varden	<83	≥83	-
burbot	<280	280–498	>498
slimy sculpin	<51	51–68	>68

Note: A hyphen or missing value indicates that we assign individual fish to the indicated life stage based only on examination of morphological indicators of sexual maturity, not based on fork-length threshold values.

Appendix B2.–Fish-anomaly classes.

Code	Name	Description
AB	Absent	Absent eye, fin, tail.
BK	Blackening	Tail or whole body with darkened pigmentation.
BL	Blisters	In mouth, just under skin.
BS	Extensive black spot	Small black cysts (dots) all over the fins and body.
CO	Copepod	A parasitic infection characterized by a worm-like copepod embedded in the flesh of the fish; body extends out and leaves a sore/discoloration at base, may be in mouth gills, fins, or anywhere on body.
CY	Cysts	Fluid-filled swellings; may be either small or large dots.
DE	Deformities	Skeletal anomalies of the head, spine, and body shape; amphibians may have extra tails, limbs, toes.
EF	Eroded fins	Appear as reductions or substantial fraying of fin surface area.
EG	Eroded gills	Gill filaments eroded from tip.
EX	Exophthalmia	Bulging of the eye.
FA	Fin anomalies	Abnormal thickenings or irregularities of rays
FU	Fungus	May appear as filamentous or "fuzzy" growth on the fins, eyes, or body.
GR	Grubs	White or yellow worms embedded in muscle or fins.
HM	Hemorrhaging	Red spots on mouth, body, fins, fin bases, eyes, and gills.
IC	Ich	White spots on the fins, skin or gills.
LE	Lesions	Open sores or exposed tissue; raised, granular, or warty outgrowths.
LI	Lice	Scale-like, mobile arthropods.
MU	Mucus	Thick and excessive on skin or gill, or as long cast from vent.
NO	None	No anomalies present.
OT	Other	Anomalies or parasites not specified.
SA	Scale anomalies	Missing patches, abnormal thickenings, granular skin
SO	Shortened operculum	Leaves a portion of the gill chamber uncovered
TU	Tumors	Areas of irregular cell growth which are firm and cannot be easily broken open when pinched. (Masses caused by parasites can usually be opened easily.)
WR	Leeches	Annelid worms which have anterior and posterior suckers. They may attach anywhere on the body.

Source: McCormick and Hughes 1998.

Appendix B3.–Fish-passage barrier classes.

Code	Name	Description
EBD	Ephemerally Fixed, Beaver Dam	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a beaver dam. Used where the location of the barrier to movement is known within 100 m.
EDJ	Ephemerally Fixed, Debris Jam	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a debris jam. This category is restricted to small scale (?10 m) features that do not dramatically alter the overall channel type. Larger mass-wasting created barriers fall in the EGD category. Used where the location of the ultimate barrier to movement is known within 100 m.
EGD	Ephemerally Fixed, Hydro-Geomorphically Dynamic	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by current hydrological or geomorphic conditions but where evidence indicates that these landscape-scale conditions are in flux over brief (decades) geologic time. Used in areas of recent or ongoing geomorphic alteration (e.g., glacial advance or retreat, mass wasting, tectonic movements, dynamic channel formation). Used where the location of the barrier to movement is within 100 m.
ELF	Ephemerally Fixed, Low Flow	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by low stream flow, but where evidence indicates that at higher stream flow, fish could ascend further up the channel. Used where the location of the barrier to movement is known within 100 m.
EOT	Ephemerally Fixed, Other	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a non-permanent barrier other than those listed immediately above. Used where the location of the ultimate barrier to movement is known within 100 m.
ESS	Ephemerally Fixed, Spring Source	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling or on-site analysis, to be blocked by the emergence of ground water from an unconfined substrate. Compare to GSL. Used where the location of the barrier to movement is known within 100 m.
GLK	Geologically Fixed, Lake Shore	Where the upstream movements of a given species appear, based on sufficient sampling or on-site analysis, to be limited by the perimeter of a geologically-stable lake shore. Used where the location of the barrier to movement is known within 100 m.
GOT	Geologically Fixed, Other	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling or on site analysis, to be blocked by a geologically fixed barrier other than those listed immediately above. Used where the location of the ultimate barrier to movement is known within 100 m.
GSL	Geologically Fixed, Stream Limit	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling or on-site analysis, to be limited to the presence of surface water, and where that presence of surface water appears to be fixed in space and stable in time (compare to ELF). Spring-fed headwall pools are examples. Used where the location of the barrier to movement is known within 100 m.

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Code	Name	Description
GWG	Geologically Fixed, Waterfall/High Gradient	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling or on-site analysis, to be blocked by a waterfall, cascade, or other similar geologically fixed barrier. Used where the location of the barrier to movement is known within 100 m.
HCU	Human, Culvert	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a culvert through a road bed, a railroad bed, a runway, or through any other type of fill. This code includes culverts of all materials (e.g., metal, plastic, wood) and shapes (e.g., round, arched, bottomless) Used where the location of the barrier to movement is known within 100 m.
HDB	Human, Debris	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by debris placed or deposited in the stream as the direct result of human activities but where that material was not intentionally placed to impound, filter, or divert stream flow. Examples include woody debris from logging activities, and debris flows from failed road prisms. Used where the location of the barrier to movement is known within 100 m.
HDM	Human, Dam	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a dam, weir, head gate, or other cross channel structure that impounds, filters, or diverts stream flow. This code includes structures of all materials (e.g., earth, concrete, rip rap, metal, wood). Used where the location of the barrier to movement is known within 100 m.
HOT	Human, Other	Where the upstream movements of a given species appear, based on sufficient upstream and downstream sampling, to be blocked by a human-created structure other than those listed immediately above. Used where the location of the barrier to movement is known within 100 m.
NAP	Not applicable	No fish observed. See downstream stations.
NON	None	No barrier exists at survey station.
SBU	Specific Barrier Unknown	Where a given species is collected at a downstream station and not at an upstream station but where no specific barrier is known between the 2 stations. Used where the distributional limits are not known within 100 m.
UNK	Unknown	No information exists upstream of a sample station. Often where a species is collected at a station and no additional sampling or survey occurs upstream.

Appendix B4.–Water color and substrate classes.

Water-color classes.

Code	Description	Definition
CLR	Clear	Transparent water, or nearly so.
FER	Ferric	Rust- (orange) stained.
GHT	Glacial, High Turbidity	High turbidity waters (visibility ≤ 30 cm (12 in) typical of streams originating directly from glaciers (e.g., Matanuska River).
GLT	Glacial, Low Turbidity	Low turbidity waters (visibility > 30 cm) typical of systems with large lakes (settling basins) below glacial discharge (e.g., Kenai River). These waters are frequently turquoise-colored.
HUM	Humic	Tea-colored water (tannic)
MUD	Muddy	Dark water with high suspended particulate load.

Substrate classes.

Code	Name	Intermediate-axis dimensions
BED	Bedrock	> 4,096 mm. Solid rock—few or no discrete particles
BLD	Boulder	256–4,096 mm
CBL	Cobble	64–256 mm
GRV	Gravel	2–64 mm
SND	Sand	0.0625–2 mm
SCL	Silt/Clay	≤ 0.0625 mm
ORG	Organic	Incompletely-decomposed organic material

Source: adapted (Bedrock and Organic classes added) from Cummins (1962), which is based on the Wentworth (1922) scale.

Appendix B5.–Fish species codes.

Code	Common name	Scientific name
ACI	sturgeon-unspecified	*Acipenser* sp.
ATG	green sturgeon	*Acipenser medirostris*
ATW	white sturgeon	*Acipenser transmontanus*
CAC	Arctic char	*Salvelinus alpinus*
CBT	brook trout	*Salvelinus fontinalis*
CDV	Dolly Varden	*Salvelinus malma*
CHR	char-unspecified	*Salvelinus* sp.
CLK	lake trout	*Salvelinus namaycush*
DAL	Alaska blackfish	*Dallia pectoralis*
ERC	trout-perch	*Percopsis omiscomaycus*
FAR	Arctic flounder	*Pleuronectes glacialis*
FLN	righteye flounders-unspecified	Pleuronectidae
FST	starry flounder	*Platichthys stellatus*
GAD	cod-unspecified	Gadidae
GAR	Arctic cod	*Boreogadus saida*
GBR	burbot	*Lota lota*
GPA	Pacific cod	*Gadus macrocephalus*
GRA	Arctic grayling	*Thymallus arcticus*
GSA	saffron cod	*Eleginus gracilis*
HAM	American shad	*Alosa sapidissima*
HER	herrings-unspecified	Clupeidae
HPA	Pacific herring	*Clupea pallasii*
IDA	salmonid, unspecified	Salmonidae
KNS	ninespine stickleback	*Pungitius pungitius*
KSB	stickleback-unspecified	Gasterosteidae
KTS	threespine stickleback	*Gasterosteus aculeatus*
LAC	Arctic-Alaskan brook lamprey paired species	*L. camtschatica / L. alaskense*
LAK	Alaskan brook lamprey	*Lampetra alaskense*
LAR	Arctic lamprey	*Lampetra camtschatica*
LMO	Atlantic salmon	*Salmo salar*
LMP	lamprey-unspecified	*Lampetra* sp.
LPC	Pacific lamprey	*Lampetra tridentata*
LRV	American river lamprey	*Lampetra ayresii*
LWB	western brook lamprey	*Lampetra richardsoni*
MIN	lake chub	*Couesius plumbeus*
NOS	longnose sucker	*Catostomus catostomus*
OEU	eulachon	*Thaleichthys pacificus*
OLS	longfin smelt	*Spirinchus thaleichthys*
OPS	pond smelt	*Hypomesus olidus*
ORM	rainbow smelt	*Osmerus mordax*
OSM	smelt-unspecified	Osmeridae
OSS	surf smelt	*Hypomesus pretiosus*
PIK	northern pike	*Esox lucius*
SAM	Pacific salmon-unspecified	semelparous *Oncorhynchus sp.*
SCK	Chinook salmon	*Oncorhynchus tshawytscha*
SCM	chum salmon	*Oncorhynchus keta*

Code	Common name	Scientific name
SCO	coho salmon	*Oncorhynchus kisutch*
SPI	pink salmon	*Oncorhynchus gorbuscha*
SSE	sockeye salmon	*Oncorhynchus nerka*
TCT	cutthroat trout	*Oncorhynchus clarkii*
TRB	rainbow trout	*Oncorhynchus mykiss*
TRT	trout-unspecified	iteroparous *Oncorhynchus sp.*
UCR	coastrange sculpin	*Cottus aleuticus*
UFH	fourhorn sculpin	*Myoxocephalus quadricornis*
ULP	sculpin-unspecified	Cottidae
UPR	prickly sculpin	*Cottus asper*
UPS	Pacific staghorn sculpin	*Leptocottus armatus*
USH	sharpnose sculpin	*Clinocottus acuticeps*
USL	slimy sculpin	*Cottus cognatus*
WAK	Alaska whitefish	*Coregonus nelsonii*
WAR	Arctic cisco	*Coregonus autumnalis*
WBC	Bering cisco	*Coregonus laurettae*
WBD	broad whitefish	*Coregonus nasus*
WHB	humpback whitefish	*Coregonus pidschian*
WHC	humpback whitefish complex	*C. clupeaformis / C. nelsonii / C. pidschian*
WHF	whitefish-unspecified	Coregoninae
WIN	inconnu (sheefish)	*Stenodus leucichthys*
WLC	least cisco	*Coregonus sardinella*
WLK	lake whitefish	*Coregonus clupeaformis*
WPG	pygmy whitefish	*Prosopium coulteri*
WRN	round whitefish	*Prosopium cylindraceum*
YMA	shiner perch	*Cymatogaster aggregata*
YYP	yellow perch	*Perca flavescens*
QQQ	other species not listed	-
VVV	no collection effort	-
XXX	no fish collected or observed	-
ZZZ	general fish observation, no species information	-

Appendix B6.–Level 1 riparian vegetation communities (Viereck et al. 1992).

Code	Key	Class	Description
I	Trees > 3 m tall with canopy cover of ≥ 10%. If not, go to II.	Forest	Single stemmed woody plants at least 3 m tall at maturity and at least 10% cover.
II	Erect to decumbent woody shrubs with cover ≥ 25% OR dwarf trees (< 3 m tall) with cover ≥ 10% cover. If not, go to III.	Scrub	Scrub communities are composed of combinations of dwarf trees, and tall, low, and dwarf shrubs.
III	Herbaceous (non-woody) vegetation dominates with < 25% scrub and < 10% forest cover. If not, go to IV.	Herbaceous	Herbaceous (non-woody) vegetation with ≤25% shrub cover and <10% forest cover.
IV	< 2% vegetative cover.	Unvegetated	Less than 2% vegetative cover; either natural or anthropogenic.

Appendix B7.–Vegetation disturbance classes.

Code	Description
A	Anthropogenic Disturbance
AA	Unique
AA1	Timber Harvest
AA1a	0-1 year post-harvest
AA1b	1-5 year post-harvest
AA1c	10-20 year post-harvest
AA1d	20+ year post-harvest
AA2	Construction
AA2a	0-1 year post-construction
AA2b	1-5 year post-construction
AA2c	10-20 year post-construction
AA2d	20+ year post-construction
AA3	Enhancement/Restoration
AA3a	Bank Stabilization
AA3b	Riparian Thinning
AA3c	Fisheries Related
AA3d	Rip-Rap
AB	Repeated Seasonal
AB1	Foot Traffic
AB1a	Anglers
AB1b	Non-anglers
AB2	Vehicle Traffic
AB2a	Non-Recreational (road vehicle)
AB2b	Recreational (ATV, snowmachine)
AC	Permanent
AC1	Pervious Surfaces
AC1a	Urban/Commercial Landscaping
AC1b	Agricultural
AC1c	Gravel
AC1d	Other
AC2	Impervious Surfaces
AC2a	Parking Area
AC2b	Paved Trail/Walkway
AC2c	Concrete Wall/Abutment
N	Natural Disturbance
NA	Water/Flood
NA1	Slumping/Undercutting
NA1a	Wood Inputs
NA1b	Sediment Inputs
NA2	Sediment deposition from tributary
NB	Windthrow
NC	Glacial Retreat
ND	Fire
NE	Mass Wasting
NE1	Avalanche
NE2	Landslide
NE3	Debris Torrent
NE4	Natural Tree Mortality

Appendix B8.–Lake origin and lake type classes (Milner et al. 1997).

Lake origin	Lake type	Description
Thermokarst: Present primarily in Arctic and Western Alaska; presence of widespread retrogressive thaw slumping around lake margins; presence of visible ground-ice along lake margins.	Thaw lake	Formed in areas of permafrost as a result of melting ground-ice creating depressions from the collapsing soil and the subsequent inundation of water.
Glacial: Present throughout Alaska; within glaciated terrain distinguishable by the close proximity of other glacial formations such as drumlins, moraines, and striations.	Cirque lake	Typically circular depressions carved into the upper sections of glacial valleys. Extremely clear, cold, and sensitive to environmental disturbance. Found primarily along the coastal mountain ranges and the Alaska Range.
	Kettle lake	Formed by the melting of large blocks of ice into glacial depressions that were left behind during glacial retreat. Found in abundance in Southcentral and Southeast Alaska.
	Ice-dammed lake	Formed when active glaciers block drainages and back up water to form a lake. Massive outburst floods are common in these types of lakes. Found throughout much of Alaska.
	Moraine lake	Formed when terminal or recessional moraines block the stream originating from the retreating glacier. These lakes are common along the southern Brooks range and along the Alaskan Peninsula.

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Lake origin	Lake type	Description
Glacial continued:	Ice-scour lake	Formed by the scouring action of glaciers moving across landscapes. Scours will later be filled with water during periods of glacial retreat. Very common in arctic Alaska.
Volcanic: Present mainly along the Alaska Peninsula, the Aleutian Islands, and the Alaska Range; Distinguishable due to its position within the caldera of an active or extinct volcano.	Crater lake	Formed by the caving in of a volcanic crater leaving behind a caldera which subsequently fills with water. Typically these lakes are very clear, deep and unproductive.
Fluvial: Present throughout Alaska; distinguishable by their juxtaposition within river basins and flood plains and observable riverine processes such as sediment deposition.	Lateral lake	Formed when meandering streams deposit silt banks such that adjacent tributaries become cut-off forming lakes. Common throughout most of Alaska.
	Ox-bow lake	Formed by the deposition of sediments blocking off river meanders forming lakes within the old river channel. Common throughout Alaska.
	Deltaic lake	Formed by the excessive deposition of river sediments within large deltas, isolating sections of channels from flow. Found primarily within the deltas of many large rivers such as the Yukon and Kuskokwim rivers.
Marine: Present primarily along the low gradient coastal plains of Alaska; generally contain brackish water.	Coastal lagoon	Formed by the accumulation of drifting beach sands which cut off valleys and marine embayments.

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Lake origin	Lake type	Description
Animal: Present throughout Alaska; distinguishable by the presence of a beaver dam at the lake outlet.	Beaver pond	Formed by the backing-up of streams due to beaver activity.
Paludification: Present in Southcentral and Southeast Alaska; distinguishable by the presence of acidic "black-water" and large amounts of sphagnum moss and bogs within the drainage.	Muskeg	Formed by the poorly drained soils of Southeast and Southcentral Alaska becoming waterlogged, displacing forested land with sphagnum bogs eventually becoming lakes and ponds.

APPENDIX C. TARGET LAKE INFORMATION

Appendix C1.–Target lake information (NAD83).

Area	Lake ID	Lake name	Distance to AWC (km)[a]	Perimeter (km)	Surface area (sq. km)	Lake outlet location		Distance from base (miles)[b]
						Latitude	Longitude	
Alagnak	AL01	Unnamed	69.5	5.68	1.01	59.911	-157.237	101
	AL02	Unnamed	62.3	4.22	0.32	59.904	-156.982	97
	AL03	Unnamed	46.8	3.42	0.47	59.868	-156.968	93
	AL04	Unnamed	38.1	2.38	0.38	59.091	-156.995	16
	AL05	Unnamed	26.8	2.22	0.37	59.907	-156.653	97
	AL06	Unnamed	25.9	8	2.16	59.396	-156.869	40
	AL07	Unnamed	25.1	3.19	0.49	59.405	-157.137	47
	AL08	Unnamed	22.3	5.5	1.03	59.333	-156.931	34
	AL09	Unnamed	22.3	3.62	0.78	59.213	-156.928	22
	AL10	Unnamed	22.3	4.16	0.66	59.747	-157.17	83
	AL11	Unnamed	21.4	4.06	0.71	59.535	-156.532	56
	AL12	Unnamed	21.4	8.79	2.21	59.364	-157.056	41
	AL13	Unnamed	20.1	2.07	0.27	60.164	-156.507	126
	AL14	Unnamed	19.9	4.86	1.68	59.373	-156.318	43
	AL15	Unnamed	17.9	4.48	0.99	59.464	-156.76	47
	AL16	Unnamed	17.2	6.16	0.47	60.203	-155.87	138
	AL17	Unnamed	14.7	3.48	0.56	60.027	-156.509	111
	AL18	Unnamed	14.5	3.18	0.58	59.901	-157.496	105
	AL19	Unnamed	13.5	3.52	0.72	59.734	-157.068	80
	AL20	Unnamed	13	4.94	1.76	59.67	-156.113	78
Dillingham	DL01	Unnamed	66.7	3.37	0.65	59.08	-157.264	69
	DL02	Cascade	66.3	9.59	3.11	60.151	-159.399	135
	DL03	Unnamed	65.1	5.88	1.94	59.213	-157.237	72

-continued-

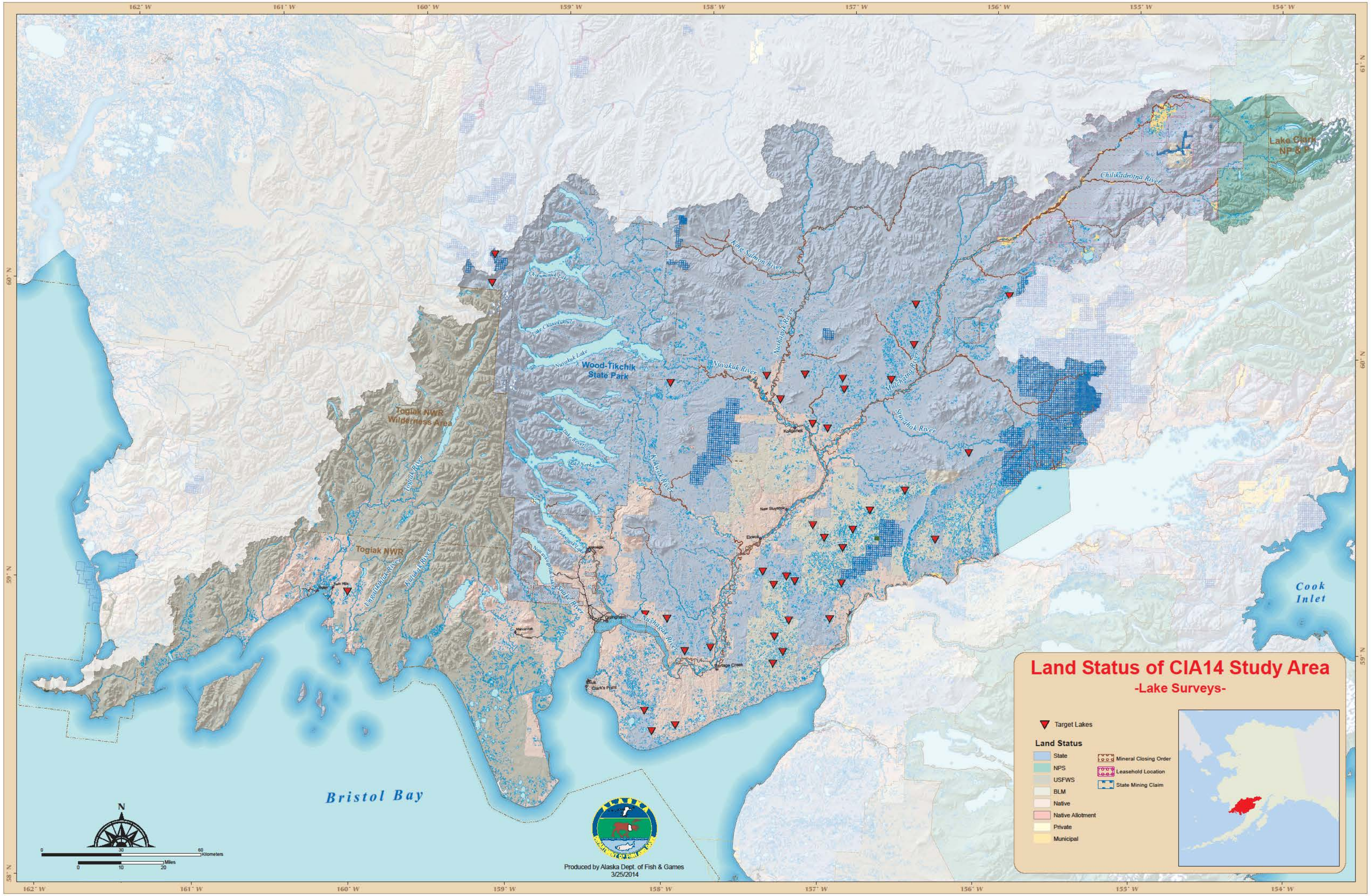
Appendix C2.–Page 2 of 2.

Area	Lake ID	Lake name	Distance to AWC (km)[a]	Perimeter (km)	Surface area (sq. km)	Lake outlet location		Distance from base (miles)[b]
						Latitude	Longitude	
Dillingham	DL08	Unnamed	37.5	3.27	0.55	58.748	-158.178	37
	DL09	Unnamed	35.8	3.2	0.59	59.197	-157.377	64
	DL10	Unnamed	31	2.92	0.39	58.972	-157.293	67
	DL11	Unnamed	26.9	6.47	1.73	59.24	-157.453	62
	DL12	Unnamed	20.5	5.87	0.9	59.823	-157.395	106
	DL13	Unnamed	19.1	4.86	0.59	58.931	-157.354	65
	DL14	Unnamed	17.4	7.81	0.94	59.073	-158.213	15
	DL15	Unnamed	16.7	3.57	0.27	58.975	-157.771	40
	DL16	Unnamed	15.5	7.79	3.3	59.069	-160.182	99
	DL17	Unnamed	15.3	6.83	2.88	58.68	-158.122	45
	DL18	Unnamed	15.3	2.69	0.51	59.063	-158.067	23
	DL19	Unnamed	14	2.77	0.53	58.957	-157.937	31
	DL20	Unnamed	13.3	2.05	0.29	59.858	-158.142	93

[a] Stream distance between target lake outlet and the upper extent of AWC coverage.

[a] Strait-line distance from the base camp to the target lake outlet.

APPENDIX D. LAND STATUS MAP



Appendix D1.–Study area land status map.

APPENDIX E. SAFETY PROTOCOLS

Appendix E1.–Bear safety.

The following outline, used by permission, accompanies the video *Staying safe in bear country*, which will be mandatory viewing for all field crew members.

Main Messages of the Video

STAYING SAFE IN BEAR COUNTRY

Safety in Bear Country Society, 2001

BEAR'S CHARACTERISTICS, BEHAVIOR AND SOCIETY

MIND OF BEARS

☐Bears are intelligent.
☐Curious
☐Individuals
☐More predictable than most people think.

PHYSICAL TRAITS

☐Amazing noses and ears and eyes are good.
☐Strong and fast, good swimmers.
☐Black bears are great at tree climbing, but grizzlies are not bad.

BLACK VS GRIZZLY BEARS

☐Grizzly distribution more limited but locally can be the most abundant.
☐Grizzlies more likely to attack when threatened.
☐Black bears rarely attack defensively.
☐Grizzlies more dangerous than blacks, but risks from either much less than people tend to fear.
☐Humans are more tolerant of black bears.

BEAR SOCIETY

☐Flexible social structure that allows bears to function at low densities or at concentrated food sources with reduced chance of injury.
☐Bears do fight but more often use avoidance, restraint, and posturing to prevent injury.

THREE MAJOR ASPECTS OF BEAR SOCIETY

☐Body language and vocalizations to communicate with each other
☐Dominance hierarchy or pecking order
☐Personal space

-continued-

BEARS' MOTIVATIONS

Bears have varying motivations for what they do.

- Food and the search for it dominate a bear's life
- Mating and raising offspring
- Investigating novel stimuli; curiosity
- Establishing and asserting dominance

From a safety standpoint it's important to understand the difference between "defensive" and other motivations, especially ones that might lead to "predatory" attack. It is also important to understand the psychology of bears as they grow up. There's a big difference in the mentality of a recently weaned 2 to 4 year old bear versus an adult female with cubs or an adult male.

BEAR-HUMAN INTERACTIONS

Most bears have previous experience around people and learn from each interaction. Humans usually don't even know they came close to a bear, BEARS USUALLY AVOID PEOPLE. Two major categories of bear-human interactions where bears don't avoid or even approach people: Defensive and Non-defensive.

DEFENSIVE INTERACTIONS

- Bear thinks you are a threat to itself, its cubs or its food.
- Usually you approached it and entered into its personal space, surprising or crowding it.
- Most likely will appear agitated and stressed.
- Closer you are to it before it becomes aware of you, more likely it is to react defensively.
- Almost always stop short of contact, fight/flight is triggered.
- Defensive response that results in an attack (physical contact) almost always involve grizzly bears surprised at close range, on a carcass or protecting young. The few defensive attacks by black bears have been females protecting cubs (but these are very rare).

NON-DEFENSIVE INTERACTIONS

A number of different non-defensive motivations that may appear similar to each other:

- Curious bear
- Human-habituated bear
- Food-conditioned bear
- Dominance-testing bear
- Predatory bear

AVOIDING BEAR ENCOUNTERS OR REACTING DURING ONE

AVOID BEARS WHENEVER POSSIBLE

LET BEAR YOU CANNOT AVOID KNOW YOU ARE HUMAN by talking and slowly waving your arms. Try to give the bear your scent

AVOID BEARS THAT ARE AWARE OF YOU AND UNCONCERNED

NEVER APPROACH A BEAR

-continued-

LEAVE AREA YOU ENCOUNTERED A BEAR

IF YOU HEAR VOCALIZATIONS OR SEE UNATTENDED CUBS…be extremely cautious and leave the area silently the way you came.

Review of your response during bear encounters:

- ☐Identify yourself as human to bears you cannot avoid by talking and slowly waving your arms. Try to give the bear your scent.
- ☐Increase your distance from the bear, even if it appears unconcerned.
- ☐Do not run, it could invite pursuit.

If a bear approaches you:

- ☐Stand your ground!
- ☐Quickly assess the situation. Is the bear behaving defensively or in some other way?
- ☐Remain calm, attacks are rare.
- ☐Do not run unless you're absolutely sure of reaching safety.
- ☐Group together. Prepare your deterrent

If the bear is approaching in a defensive manner:

- ☐Stand your ground. Try to appear non-threatening.
- ☐Don't shout at the bear. Talk to the bear in a calm voice.
- ☐If the bear stops its approach, increase your distance.
- ☐If the bear resumes its approach, stand your ground, keep talking calmly, and prepare to use your deterrent.
- ☐If the bear cannot be deterred and is intent on attack, fall to the ground as close to contact as possible and play dead.
- ☐When the attack stops, remain still and wait for the bear to leave. If an attack is prolonged or the bear starts eating you, it is no longer being defensive.

If the bear approaches in a non-defensive manner:

- ☐Talk to the bear in a firm voice.
- ☐Try to move away from the bear's travel path; that may be all it wants you to do.
- ☐If the bear follows you with its attention directed at you. Stop! Stand your ground and prepare to use your deterrent.
- ☐Act aggressively toward the bear. Let the bear know you will fight if attacked. Shout! Make yourself look as big as possible. Stamp your feet as you take a step or two toward the bear. Threaten the bear with whatever is at hand. A bear that is initially curious or testing you may become predatory if you do not stand up to it. The more the bear persists, the more aggressive your response should be.
- ☐If the bear attacks, use your deterrent and fight for your life. Kick, punch, or hit the bear with whatever weapon is available. Concentrate your attack on the face, eyes, and nose. Fight any bear that attacks you in your building or tent.

Remember:

- ☐If an attack (that is, physical contact is made) is defensive… Play dead. (Don't play dead before you have used all possible means, such as deterrents to prevent an attack).

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- ☐ If the attack is predatory… Fight back.

HELPING SOMEONE BEING ATTACKED

You may be able to drive away an attacking bear from someone else, but if you do this you risk drawing the attack to yourself.

DETERRENTS AND PREVENTING PROBLEMS

DETERRENTS

BEAR SPRAY

- ☐ Used to deter bears at close range.
- ☐ It is not 100 percent effective or a substitute for avoiding an encounter.
- ☐ Use only approved bear sprays.
- ☐ Carry it ready to use and keep it handy in your tent at night.
- ☐ Exercise caution

FIREARMS

- ☐ Make sure it's adequate
- ☐ Practice
- ☐ Mentally rehearse the situations where you would use it.

DETERRENTS IN GENERAL

- ☐ Know their capabilities and limitations.
- ☐ Can be useful but should not give you a false sense of security.
- ☐ Training and practice are essential.
- ☐ Observe regulations governing their transport and use.
- ☐ Consult with local authorities.

PREVENTING BEAR PROBLEMS

Most of bear safety is prevention.

LEARN ABOUT BEARS

AVOID ENCOUNTERS

- ☐ Move away undetected from bears that are unaware of you or distant.

STAY ALERT

Be aware of your surroundings.

-continued-

☐Look for signs of recent bear activity.

DON'T SURPRISE BEARS

☐Warn bears of your presence.

TRAVEL IN A GROUP

☐Groups are noisier and easier to detect and several people are more intimidating to a bear.

KEEP CHILDREN CLOSE

DOGS

☐Keep it on a leash or leave it at home. The exception is a specially trained dog, but most dogs are not.

CHOOSE CAMPSITES CAREFULLY

☐Don’t camp on bear travel routes
☐Use local knowledge of bears and recommended camping practices.

DON'T ATTRACT BEARS OR REWARD THEM WITH FOOD

☐Keep a clean camp free of attractants.

OTHER DETECTION/DETERRENT OPTIONS

☐Trip wires, motion detectors and compact electric fences can be useful

FIRST AID

☐Be proficient in first aid.
☐Carry sufficient medical supplies.

COMMUNICATION

☐Inform others of your plans.
☐Communication can save lives.

Appendix E2.–Electrofishing safety.

For 2014, all electrofishing crew leaders are required to have attended an approved electrofishing course. Other electrofishing crewmembers will receive an electrofishing orientation (see Appendix E3) and be directly-supervised by the crew leader at all times while electrofishing. All crewmembers will be certified in 1st Aid and adult CPR.

The following was adapted from McCormick and Hughes, 1998:

Because fishes are collected using electrofishing units, safety procedures must be followed meticulously at all times. Primary responsibility for safety while electrofishing rests with the electrofishing team leader. Electrofishing units have a high voltage output and may deliver a dangerous electrical shock.

While electrofishing, avoid contact with the water unless sufficiently insulated against electrical shock. Use chest waders or hip boots with nonslip soles and watertight rubber (or electrician's) gloves. If they become wet inside, **stop fishing until they are thoroughly dry. Avoid contact with the anode and cathode at all times due to the potential shock hazard.** If you perspire heavily, wear polypropylene or some other wicking and insulating clothing instead of cotton.

While electrofishing, avoid reaching into the water. If it is necessary for a team member to reach into the water to pick up a fish or something that has been dropped, **do so only after the electrical current has been interrupted and the anode is removed from the water**. Do not resume electrofishing until all individuals are clear of the electroshock hazard.

Avoid operating electrofishing equipment near unprotected people, or non-target animals. Discontinue activity during thunderstorms or heavy rain.

Team members should keep each other in constant view or communication while electrofishing. Although the electrofishing team leader has authority, each team member has the responsibility to question and modify an operation or decline participation if it is unsafe.

Appendix E3.–Acknowledgment of electrofishing orientation.

Acknowledgment of Electrofishing Orientation

I have received instruction and orientation about Electrofishing from my employer. As a result, I understand and accept the following conditions:

1. Electrofishing (EF) is an inherently hazardous activity in which safety is the primary concern. The electrical energy used in EF is sufficient to cause death by electrocution.
2. During operations, it is critical to avoid contact with the electrodes and surrounding water. The EF field is most intense near the electrodes and can extend 5-10 m outward.
3. The electrodes are energized by the power source, a generator or battery, and controlled by safety switches; these switches must remain off until the signal is given to begin EF.
4. The power source has a main switch that must be turned off immediately if an emergency occurs.
5. The electrodes are usually metal probes suspended in the water. If direct current is issued from a boat, the anodes (+) are in front of the boat to catch fish and the cathodes (-) may be suspended from the sides; both can produce electroshock. When a metal boat is the cathode, the boat is safe as long as all metal surfaces inside it are connected to the hull.
6. Moveable anodes on a boat are dangerous, especially on metal boats. All electrodes on a conventional EF boat should be in fixed position during operation.
7. Dry skin and clothing are good protection against electroshock. The body should be fully clothed during EF. Rubber knee boots are minimal foot protection, as are rubber gloves for the hands. A personal flotation device must be worn when the water is considered swift, cold, or deep. Ear protection is necessary for those working near the generator.
8. At least 2 members of the EF crew must have knowledge of CPR and first aid. A first aid kit and, in an EF boat, a fire extinguisher must be within immediate reach during an operation. Electroshock can cause heart fibrillations or respiratory arrest; CPR can cure only the latter. The EF crew must know the location of the nearest defibrillation unit.
9. A communication system, particularly hand signals, must be available to all members of an EF crew. When multiple anodes are used in a portable EF operation, the buddy system must be used. Above all, NEVER OPERATE ALONE.
10. Stunned fish should be removed from the EF field as soon as possible and not subjected to continuous electroshock by being held in the dip net. Using the anode as a dip net is unhealthy for fish and people and should be avoided.
11. An EF operation should proceed slowly and carefully; avoid chasing fish and other sudden maneuvers. Night activities require bright, bow-mounted headlights. Operations should crease during lightning or thunderstorms; use discretion during rain. Avoid EF too close to bystanders and pets or livestock.
12. All EF crewmembers must know who their leader is and recognize his or her authority as final in operational decisions. However, every crewmember has the right to ask questions or express concern about any safety aspect of an EF operation. A crewmember has the right to decline participation in an EF operation, without fear of employer recrimination, if he or she feels unsafe in such participation.

____ __________

Signature of Employee Date

I have discussed the above-named conditions with the employee and am satisfied that he or she understands them.

____ __________

Signature of Supervisor Date

*Adapted from Reynolds (1996), with permission.

APPENDIX F. EQUIPMENT LIST

Appendix F1.– Field equipment list.

Group	Item	Estimated wt (lb)	Team-A (lakes) qty	Team-A (lakes) Total wt (lb)	Spare qty	Spare Total wt (lb)
crew gear	bug dope: 30-40% DEET	0	1	0	1	0
crew gear	bug dope: 90% DEET	0	1	0	1	0
crew gear	clipboard – metal	0	1	0	0	0
crew gear	dry bag	0.5	1	0.5	1	0.5
crew gear	ear plugs	0	2	0	20	0
crew gear	field notebooks - Rite in the Rain	0	2	0	2	0
crew gear	field data sheets	1	0	0	1	1
crew gear	wader repair kit	1	2	2	1	1
crew gear	head nets	0	2	0	0	0
crew gear	marker - Sharpie fine, mixed colors	0	2	0	2	0
crew gear	marker - Sharpie ultra fine, mixed colors	0	2	0	4	0
crew gear	pencil (9-mm mechanical)	0	2	0	2	0
crew gear	PFD	2	2	4	1	2
crew gear	radio - battery for ICOM IC-A6	0.25	1	0.25	1	0.25
crew gear	radio – ICOM IC-A6	1	1	1	1	1
crew gear	rubber gloves	0.5	2	1	1	0.5
crew gear	sun block	1	1	1	0	0
crew gear	sunglasses, polarized	0	3	0	0	0
crew gear	survival knife	0	3	0	0	0
crew gear	whistle	0	3	0	0	0
electrofisher	1-gal gas can for GPP 2.5	1	1	1	0	0
electrofisher	anode spider array for GPP 2.5	5	2	10	1	5
electrofisher	dipnet with 6-ft fiberglass handle	5	1	5	1	5
electrofisher	electrofisher - Smith-Root GPP 2.5 (generator; control box; cables; foot switch, anode poles)	120	1	120	0	0
electrofisher	fire extinguisher	10	1	10	0	0
electronics	GPS unit (Garmin GPSmap 76S, or comp.), with data transfer cable	0.5	1	0.5	0	0
electronics	Itronix ultra-rugged notebook PC	10	1	10	0	0
fish gear	Gill net w/ lead and float line, buoys and anchors	5	4	20	0	0
fish gear	live well (cooler)	10	1	10	0	0
fish gear	measuring board - large (30-in)	3	1	3	0	0
fish gear	measuring board - small (10-in)	0	1	0	1	0
fish gear	minnow traps with line	4	4	4	5	5
fish gear	net twine, for dipnet repair	0	1	0	1	0
fish gear	netting, ⅛-in mesh, for dipnet repair	0	1	0	1	0
fish gear	nylon stockings/bags for retaining voucher specimens	0	100	0	0	0
fish gear	pack of ~ 150 CO^2 tablets (Alka-Seltzer)	0.5	1	0.5	0	0
fish gear	AQUI-S 20E anesthetic and MSDS	0	1	0	0	0
fish gear	ZipLock bags (1 quart, 1 gal)	0	1	0	0	0
fish gear	cured salmon roe (100 sets)	5	1	0	1	5
habitat	clinometer - Suunto PM-5/360 PC	0	1	0	0	0
inflatable	battery, 12V for inflator (P/N 12/18 at Batteries Plus)	15	1	15	0	0
inflatable	inflatable boat w/frame, oars, motor (Grabner Ranger)	161	1	200	0	0
inflatable	inflator – electric	3	1	3	0	0
inflatable	inflator – manual	2	1	2	1	2
inflatable	repair kit for inflatable boat	1	1	1	0	0
optics	digital camera (Fujifilm XP10), memory card (250 MB min.), card reader	2	1	2	1	2

-continued-

Appendix F1.–Page 2 of 2.

Group	Item	Estimated wt (lb)	Team-A (lakes) qty	Team-A (lakes) Total wt (lb)	Spare qty	Spare Total wt (lb)
optics	Pelican case (1200) for digital camera & GPS	0.25	1	0.25	0	0
optics	rangefinder - Bushnell Yardage Pro	1	1	1	0	0
power	AA batteries (NIMH) for GPS (2 ea)	0	6	0	6	0
reference	Pollard et al. 1997	0	1	0	0	0
reference	species list guide book	0.25	1	0.25	0	0
repair	20 zip ties	0	1	0	1	0
repair	duct tape	0.5	1	0.5	0	0
repair	electrical tape	0	1	0	0	0
repair	tool kit (Ratchet w/ ½ in. socket, crescent wrench; needle-nose pliers; screwdrivers)	5	1	5	0	0
storage	dry storage box (York)	6	1	6	0	0
survival	12-gauge slugs: (e.g. Brenneke), box of 5	1	1	1	1	1
survival	medical kit (REI Adventure, or comp.)	3	1	3	0	0
survival	MRE/dehydrated meals	1	3	3	3	3
survival	Personal locator beacons	1	1	1	0	0
survival	satellite phone (with charger and antenna)	1	1	1	0	0
survival	shotgun (Rem. model 870 Marine Magnum)	10	1	10	0	0
survival	shotgun case - (e.g., Kolpin Gun Boot)	6	1	6	0	0
survival	survival kit (rations, signaling, fire starter, water purification, shelter)	2	1	2	0	0
survival	throw bag (75-ft, 3/8-in polypro)	2	2	4	0	0
WQ	Secchi disc	2	1	2	0	0
WQ	YSI 556 in Pelican case	8	1	8	0	0
	Total estimated weight of field equipment = 518lb			**485**		**33**

Appendix F2.–Office equipment for field trip.

Group	Item	qty	Estimated wt (lb)	Total wt (lb)
crew gear	radio - charger for ICOM IC-A6	1	3	3
crew gear	wader repair kit (breathable waders) & Aquaseal	3	0	0
electrofisher	motor oil (quarts) for GPP 2.5 (SAE 10-30)	1	1	1
electrofisher	ScotchBrite pads	2	0	0
electronics	charger for Itronix notebook PCs	1	0.5	0.5
electronics	MapSource U.S. topo software	1	0	0
electronics	spare battery for Itronix notebook PCs	1	0.5	0.5
electronics	external hard drive	1	1	1
electronics	USB card reader	1	0	0
fish gear	formalin, 10% buffered, 4L	1	8	8
fish gear	bottle; 4 L plastic, wide mouth, with cap for voucher specimens	1	0	0
power	12 V charger for inflator battery	1	1	1
power	AA battery charger	1	1	1
power	extension cord	1	1	1
power	power strip	1	0.5	0.5
reference	reference books (op-plan; instrument manuals; field guides/keys)	1	20	20
repair	shotgun cleaning kit (bore brush; rod; patches; solvent; oil; rag)	1	2	2
repair	Tri-flow (for cleaning guns)	1	0.5	0.5
storage	Roughneck totes with lids	5	1	5
WQ	conductivity standard sol'n (84 uS/cm, 500 ml)	3	1	3
WQ	pH 10 calibration standard sol'n, 500 ml	3	1	3
WQ	pH 4 calibration standard sol'n, 500 ml	3	1	3
WQ	pH 7 calibration standard sol'n, 500 ml	3	1	3
	Total estimated weight of office equipment = 57lb			

APPENDIX G. FISH SPECIES KNOWN TO OCCUR IN THE STUDY AREA

Appendix G1.–Fish species known to occur in the 2014 study area.

Species code	Common name	Scientific name
LAK	Alaskan brook lamprey	*Lampetra alaskense*
LAR	Arctic lamprey	*Lampetra camtschatica*
LPC	Pacific lamprey	*Lampetra tridentata*
NOS	longnose sucker	*Catostomus catostomus*
PIK	northern pike	*Esox lucius*
DAL	Alaska blackfish	*Dallia pectoralis*
OPS	pond smelt	*Hypomesus olidus*
ORM	rainbow smelt	*Osmerus mordax*
OEU	eulachon	*Thaleichthys pacificus*
WLC	least cisco	*Coregonus sardinella*
WHB	humpback whitefish	*Coregonus pidschian*
WBC	Bering cisco	*Coregonus laurettae*
WRN	round whitefish	*Prosopium cylindraceum*
WPG	pygmy whitefish	*Prosopium coulterii*
GRA	Arctic grayling	*Thymallus articus*
CLK	lake trout	*Salvelinus namaycush*
CAC	Arctic char	*Salvelinus alpinus*
CDV	Dolly Varden	*Salvelinus malma*
TRB	rainbow trout	*Oncorhynchus mykiss*
SPI	pink salmon	*Oncorhynchus gorbuscha*
SCO	coho salmon	*Oncorhynchus kisutch*
SCK	Chinook salmon	*Oncorhynchus tshawytscha*
SCM	chum salmon	*Oncorhynchus keta*
SSE	sockeye salmon	*Oncorhynchus nerka*
GBR	burbot	*Lota lota*
KTS	threespine stickleback	*Gasterosteus aculeatus*
KNS	ninespine stickleback	*Pungitius pungitius*
USL	slimy sculpin	*Cottus cognatus*
UCR	coastrange sculpin	*Cottus aleuticus*
FST	starry flounder	*Platichthys stellatus*

APPENDIX H. ANADROMOUS WATERS CATALOG NOMINATION FORM

Appendix H1.–Anadromous Waters Catalog nomination form.

State of Alaska
Department of Fish and Game
Division of Sport Fish

Nomination Form
Anadromous Waters Catalog

Region ______________________ USGS Quad(s) ______________________

Anadromous Waters Catalog Number of Waterway ______________________

Name of Waterway ______________________ ☐ USGS Name ☐ Local Name

☐ Addition ☐ Deletion ☐ Correction ☐ Backup Information

For Office Use

Nomination # ____________	____________ Fisheries Scientist ______ Date
Revision Year: ____________	____________ Habitat Operations Manager ______ Date
Revision to: Atlas ______ Catalog ______ Both ______	____________ AWC Project Biologist ______ Date
Revision Code: ____________	____________ Cartographer ______ Date

OBSERVATION INFORMATION

Species	Date(s) Observed	Spawning	Rearing	Present	Anadromous
					☐
					☐
					☐
					☐
					☐

IMPORTANT: Provide all supporting documentation that this water body is important for the spawning, rearing or migration of anadromous fish, including: number of fish and life stages observed; sampling methods, sampling duration and area sampled; copies of field notes; etc. Attach a copy of a map showing location of mouth and observed upper extent of each species, as well as other information such as: specific stream reaches observed as spawning or rearing habitat; locations, types, and heights of any barriers; etc.

Comments:

Name of Observer (please print): ______________________

Signature: ______________________ Date: ____________

Agency: ______________________

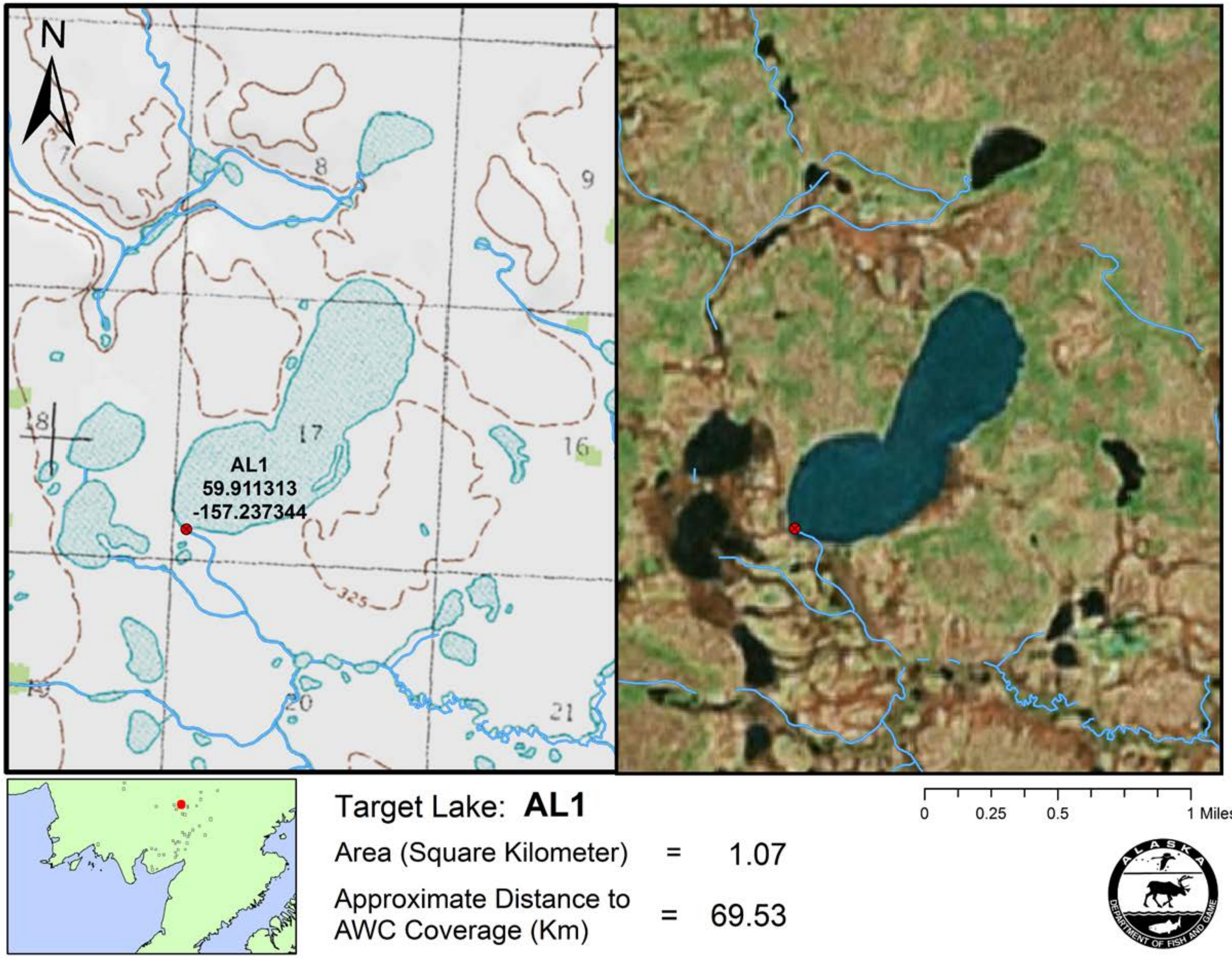
Address: ______________________

____

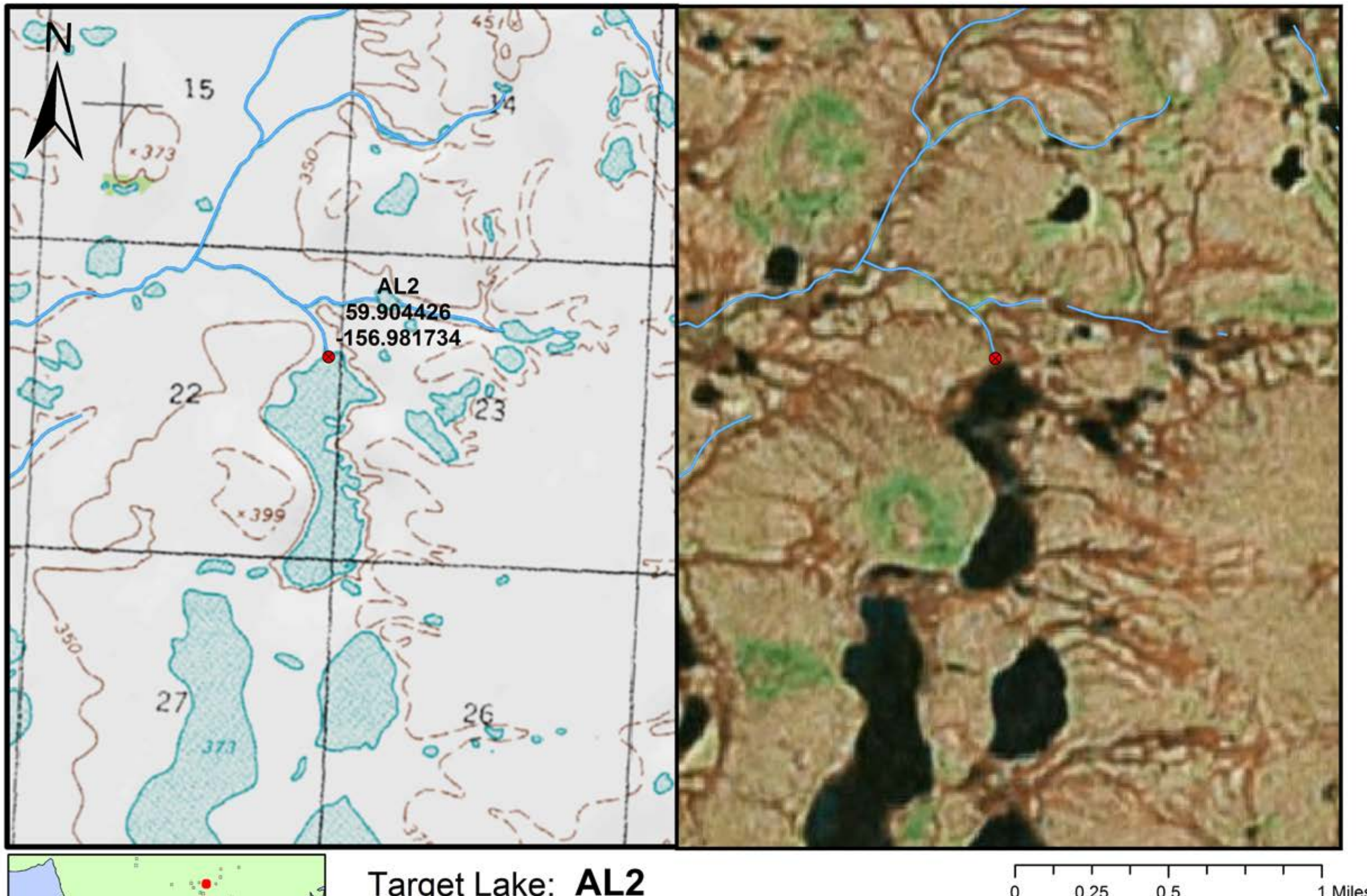
This certifies that in my best professional judgment and belief the above information is evidence that this waterbody should be included in or deleted from the Anadromous Waters Catalog.

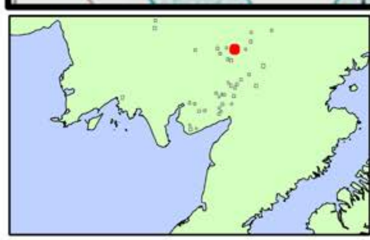
Signature of Area Biologist: ______________________ Date:______________ Revision 02/08

APPENDIX I. LAKE MAPS



Appendix I1.–AL1.



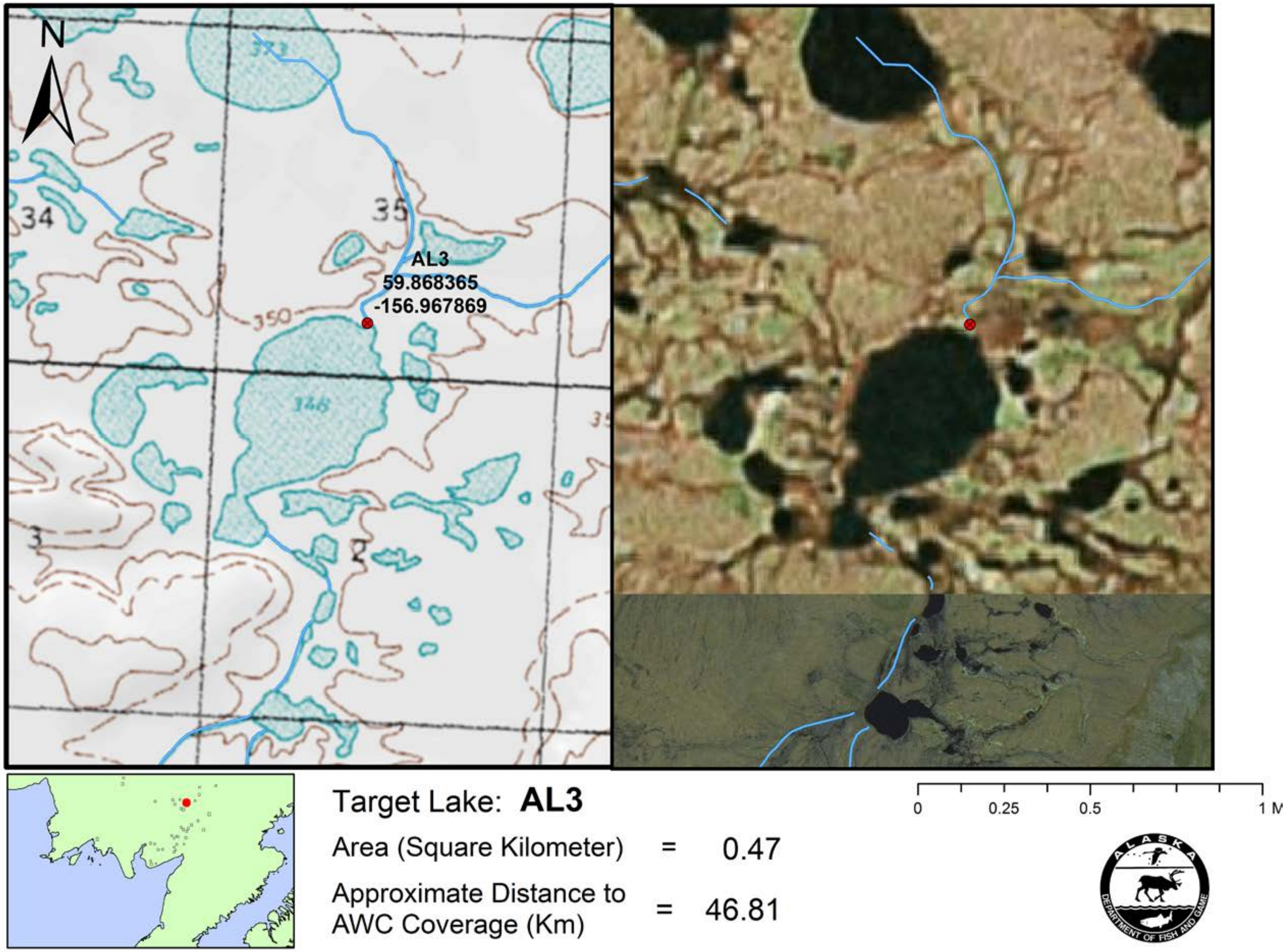


Target Lake: **AL2**

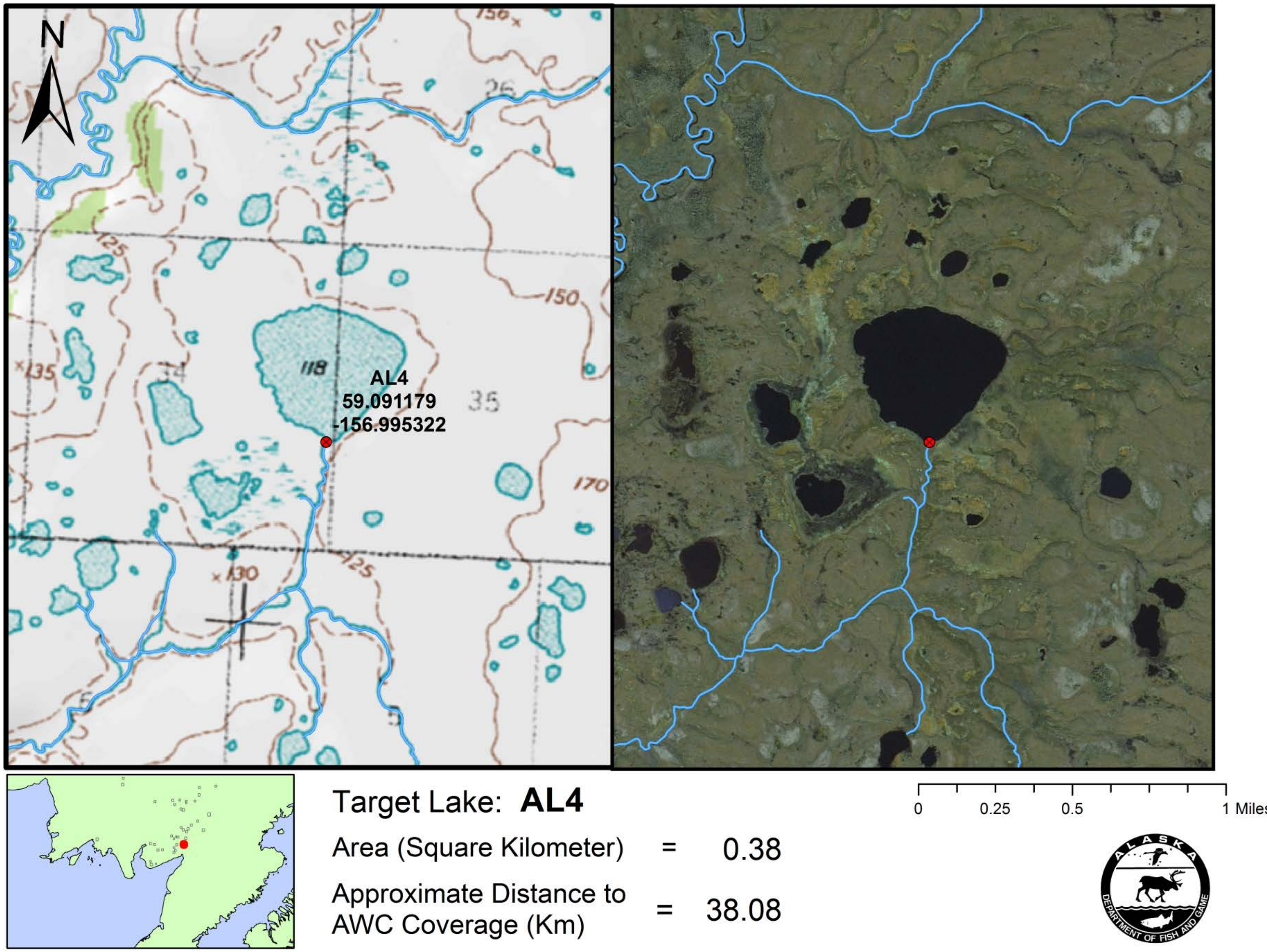
Area (Square Kilometer) = 0.32

Approximate Distance to AWC Coverage (Km) = 62.35

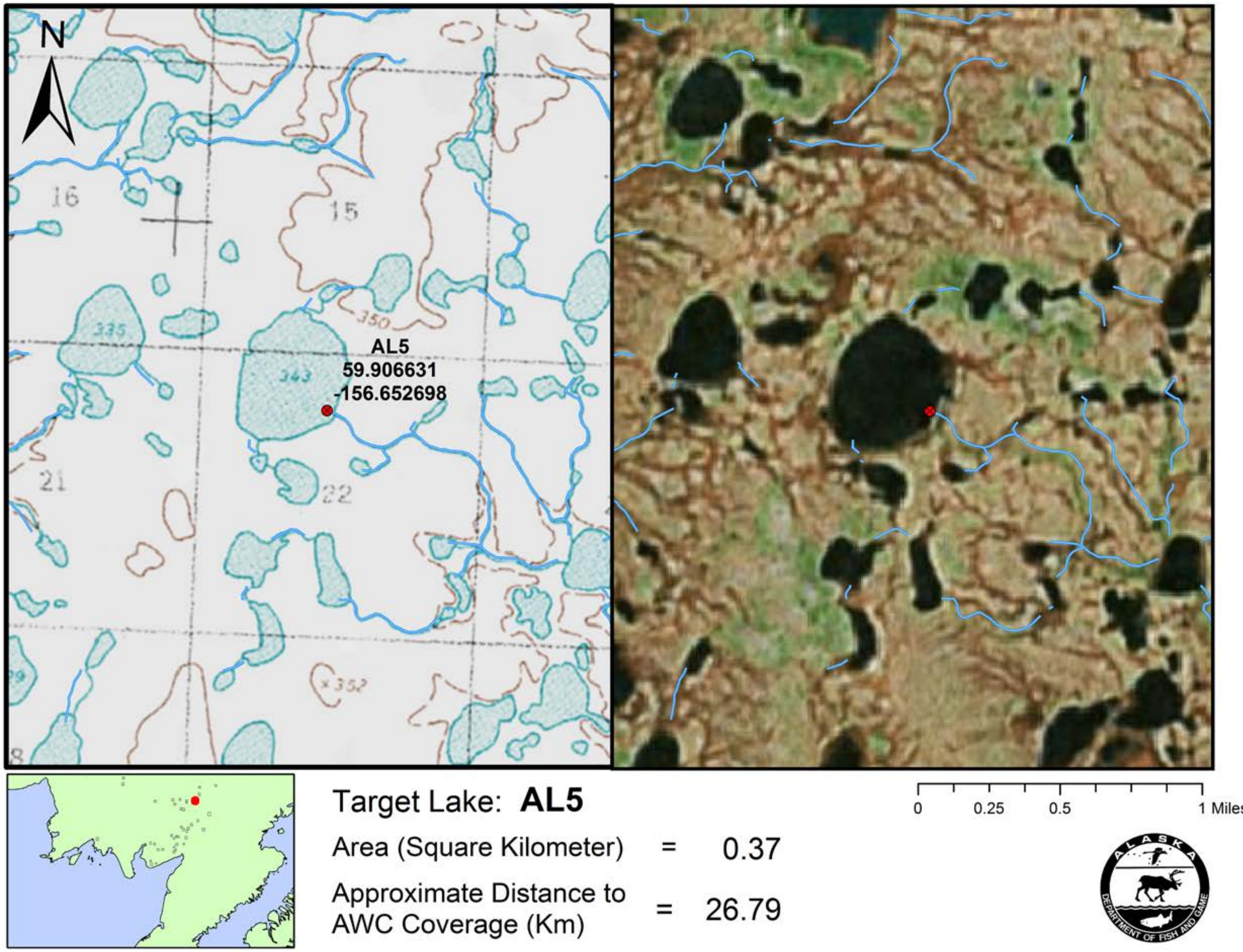
Appendix I2.–AL2.



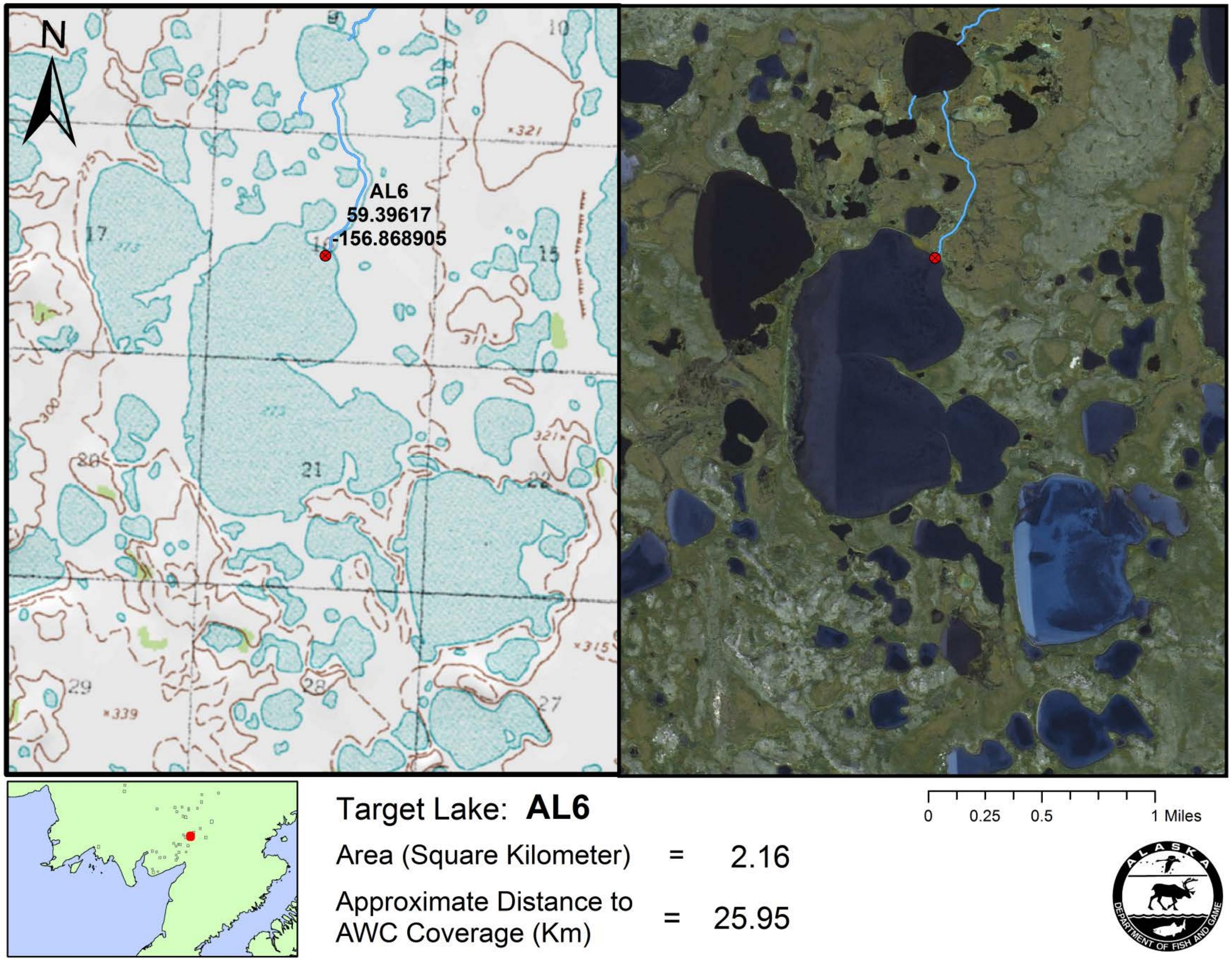
Appendix I3.–AL3.



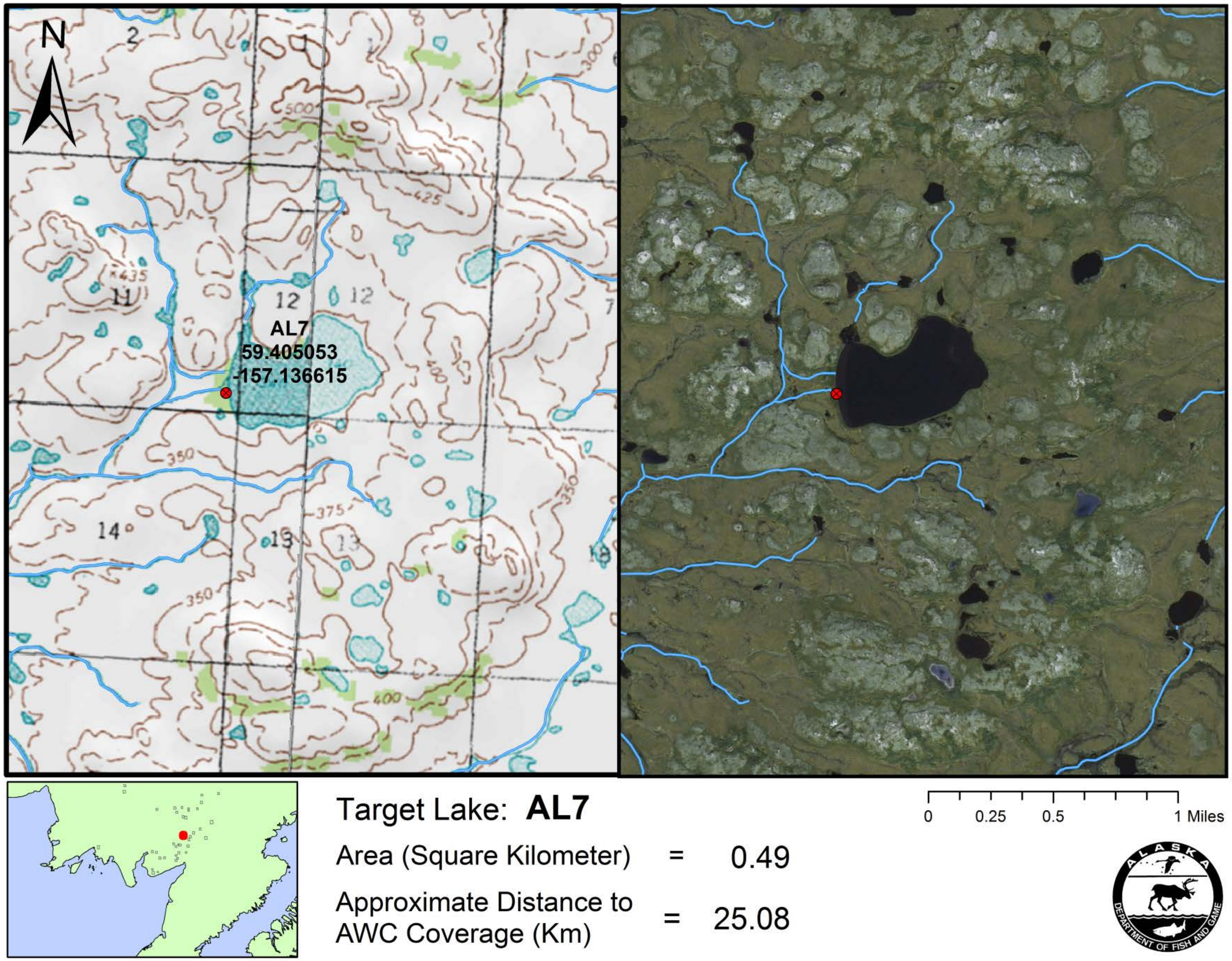
Appendix I4.–AL4.



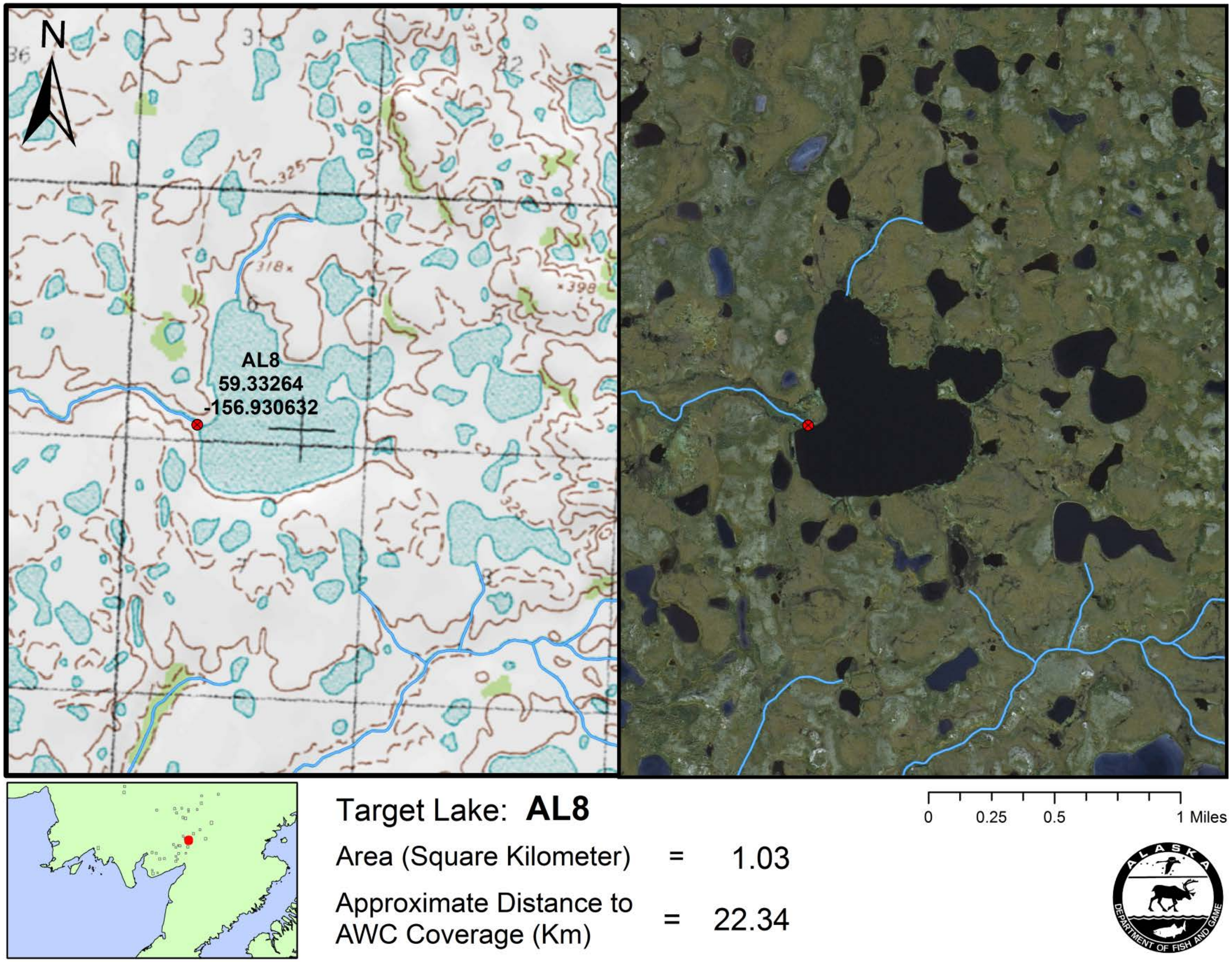
Appendix I5.–AL5.



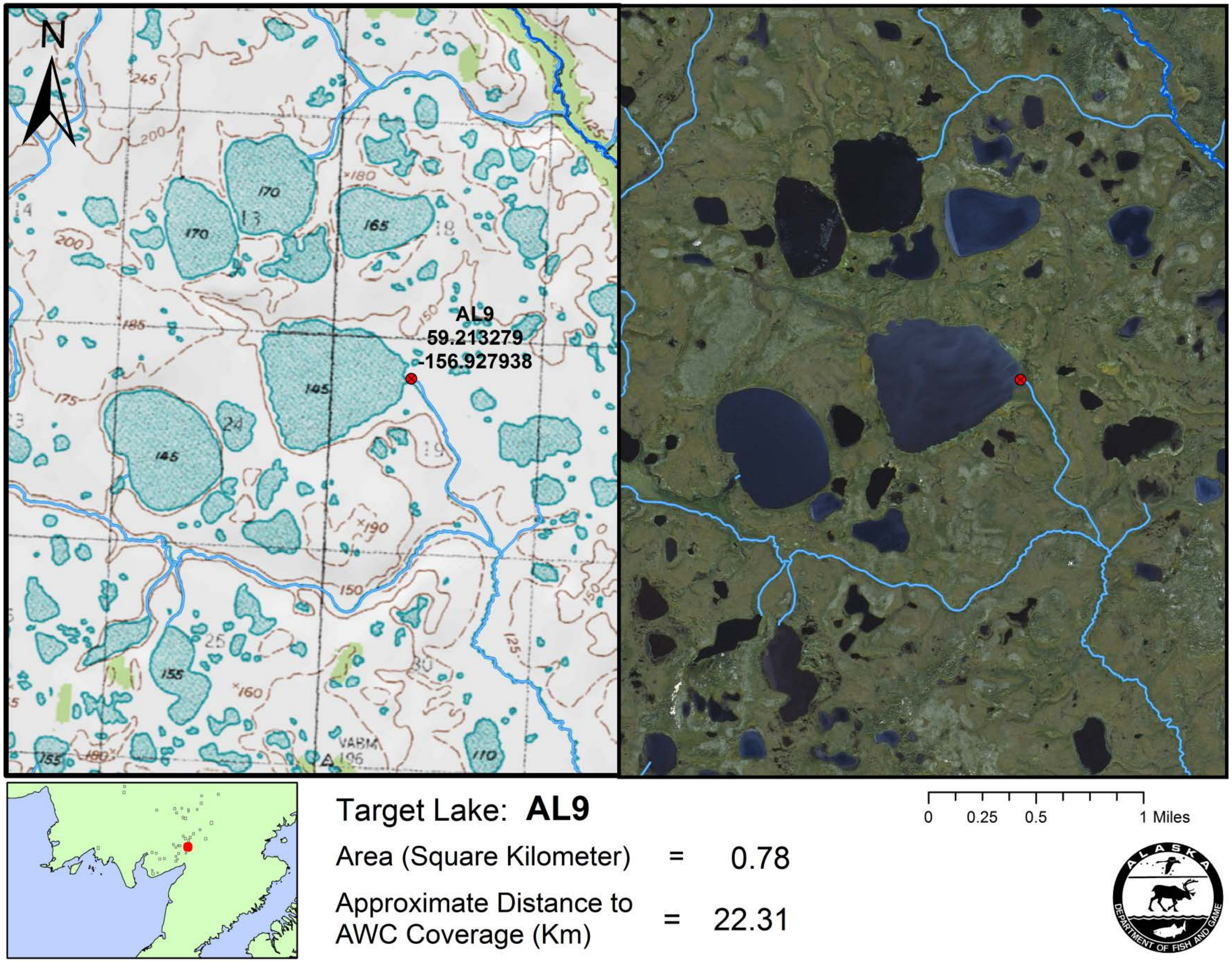
Appendix I6.–AL6.



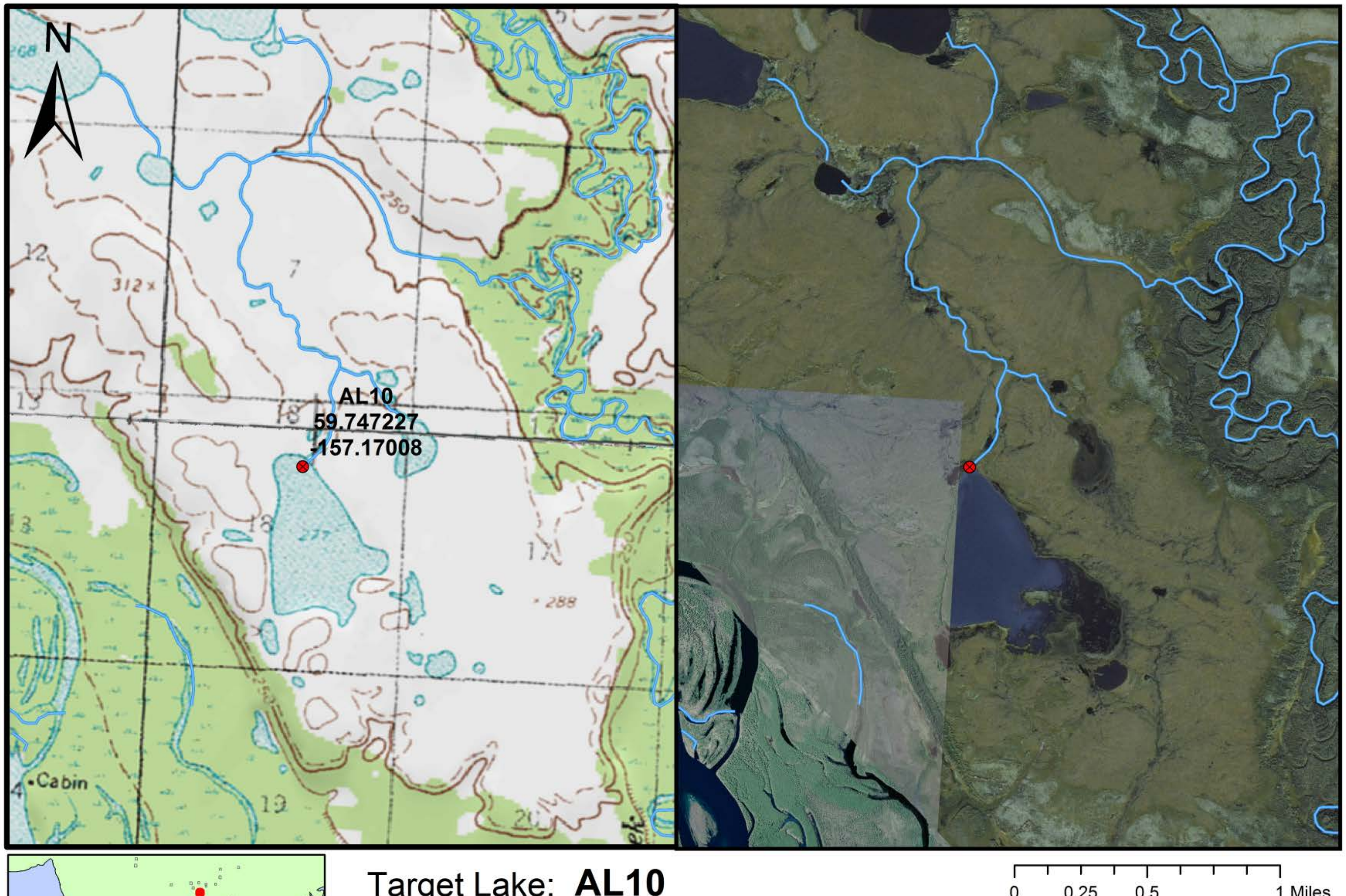
Appendix I7.–AL7.

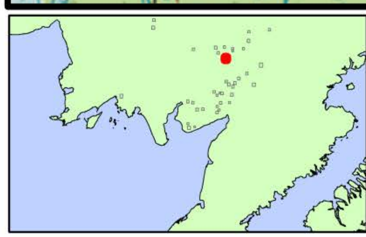


Appendix I8.–AL8.



Appendix I9.–AL9.



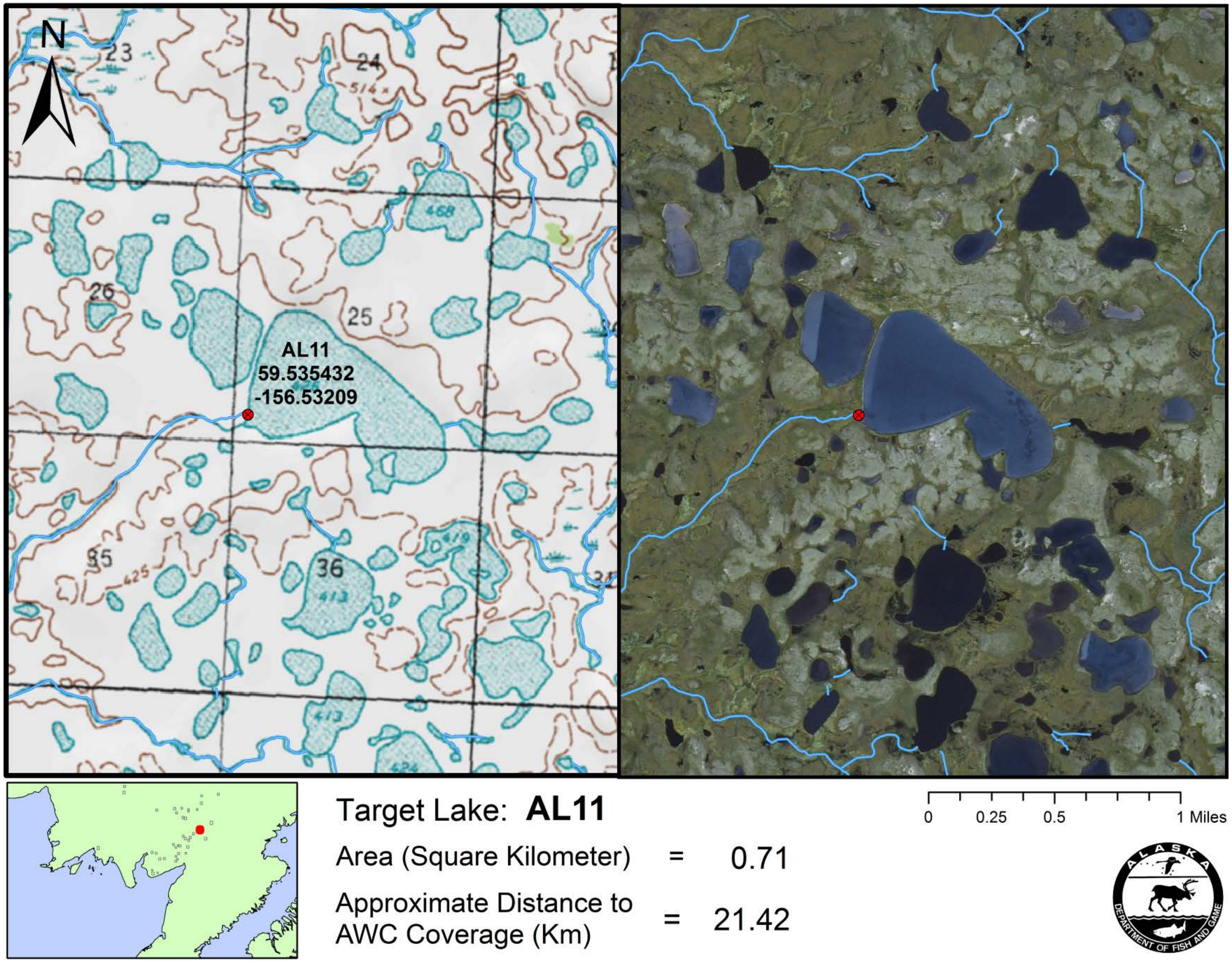


Target Lake: **AL10**

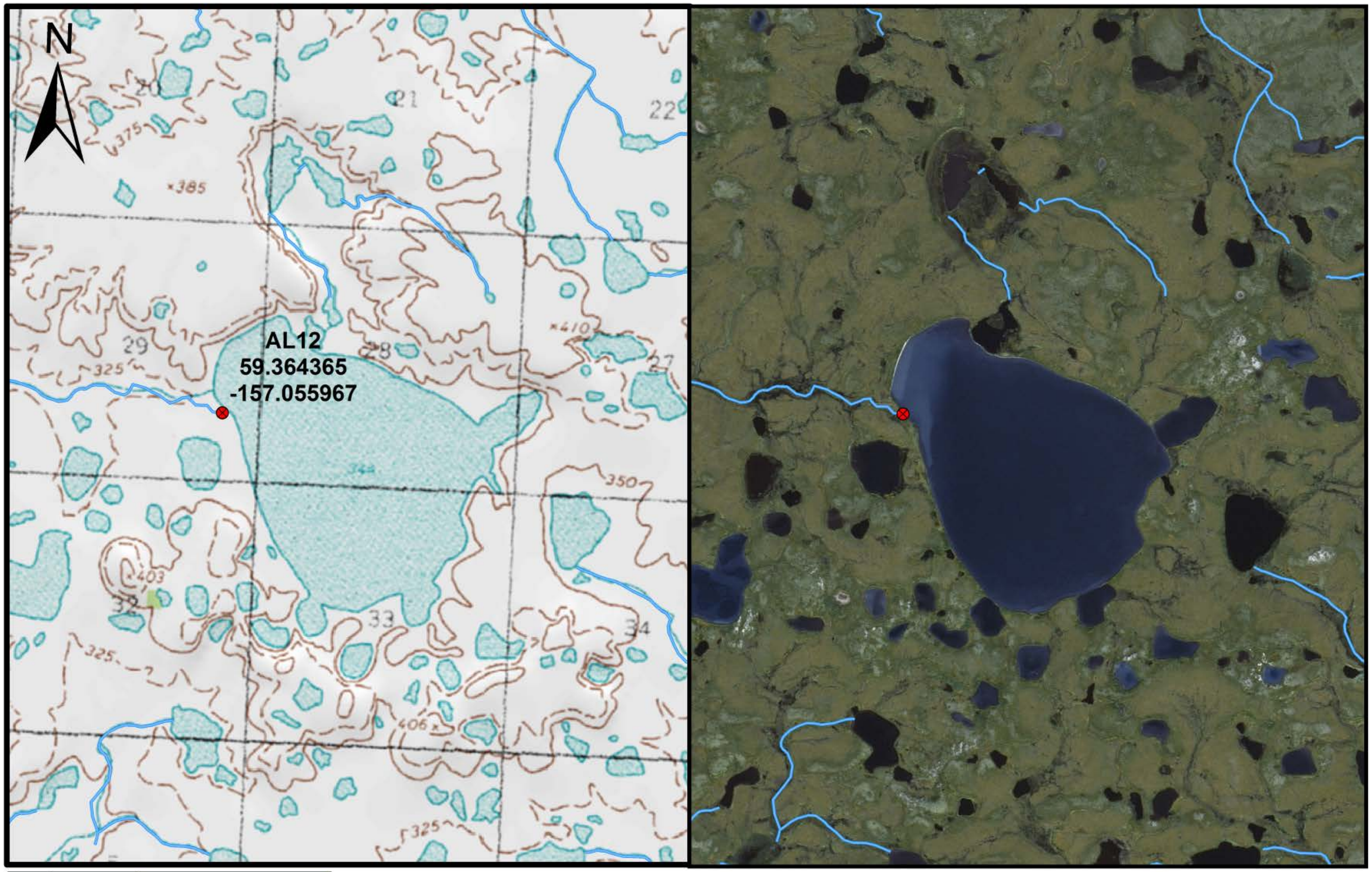
Area (Square Kilometer) = 0.66

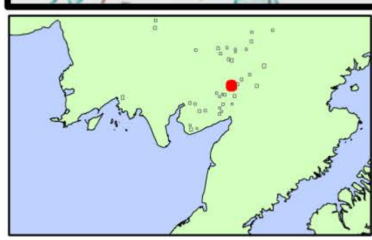
Approximate Distance to AWC Coverage (Km) = 22.28

Appendix I10.–AL10.



Appendix I11.–AL11.





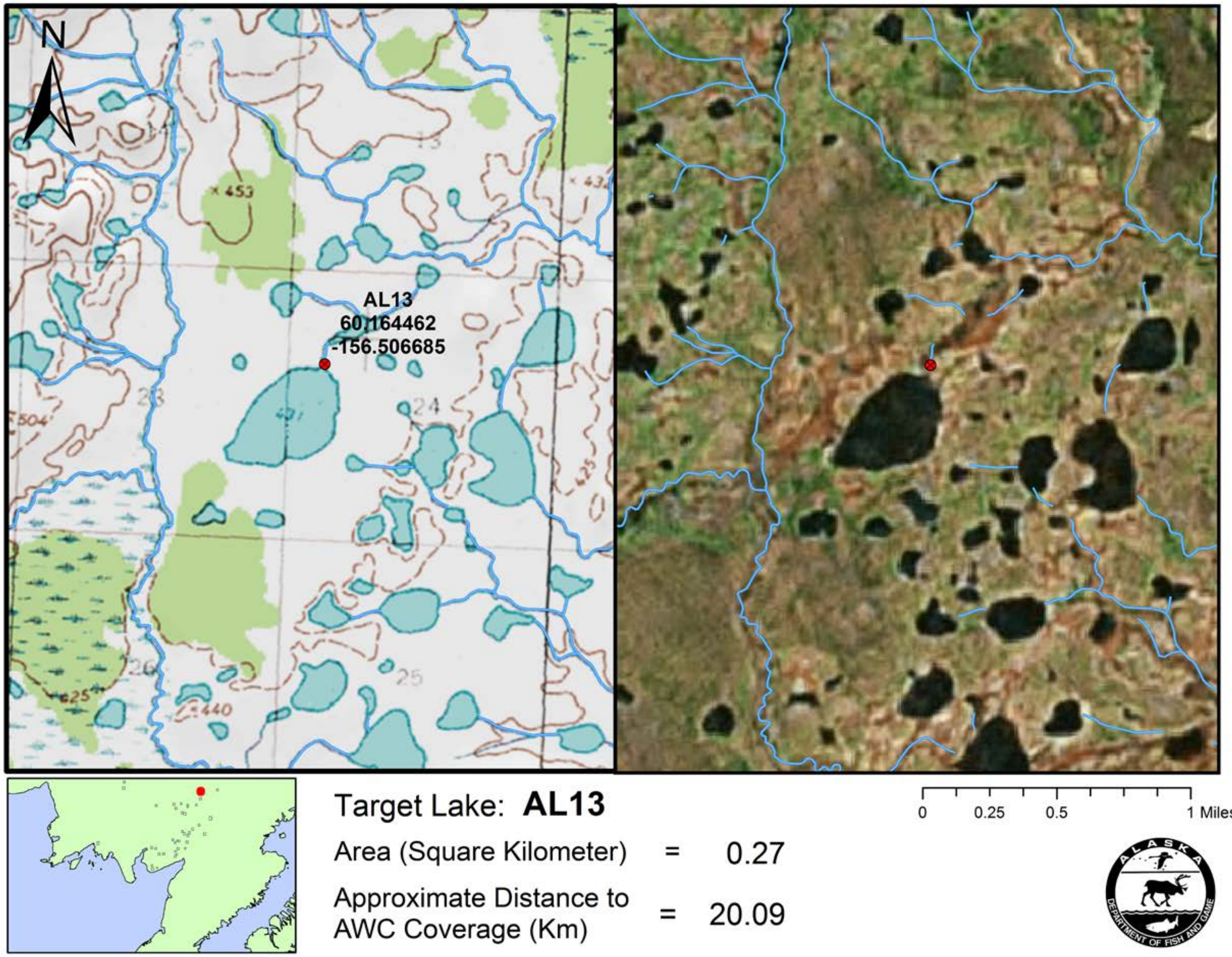
Target Lake: **AL12**

Area (Square Kilometer) = 2.21

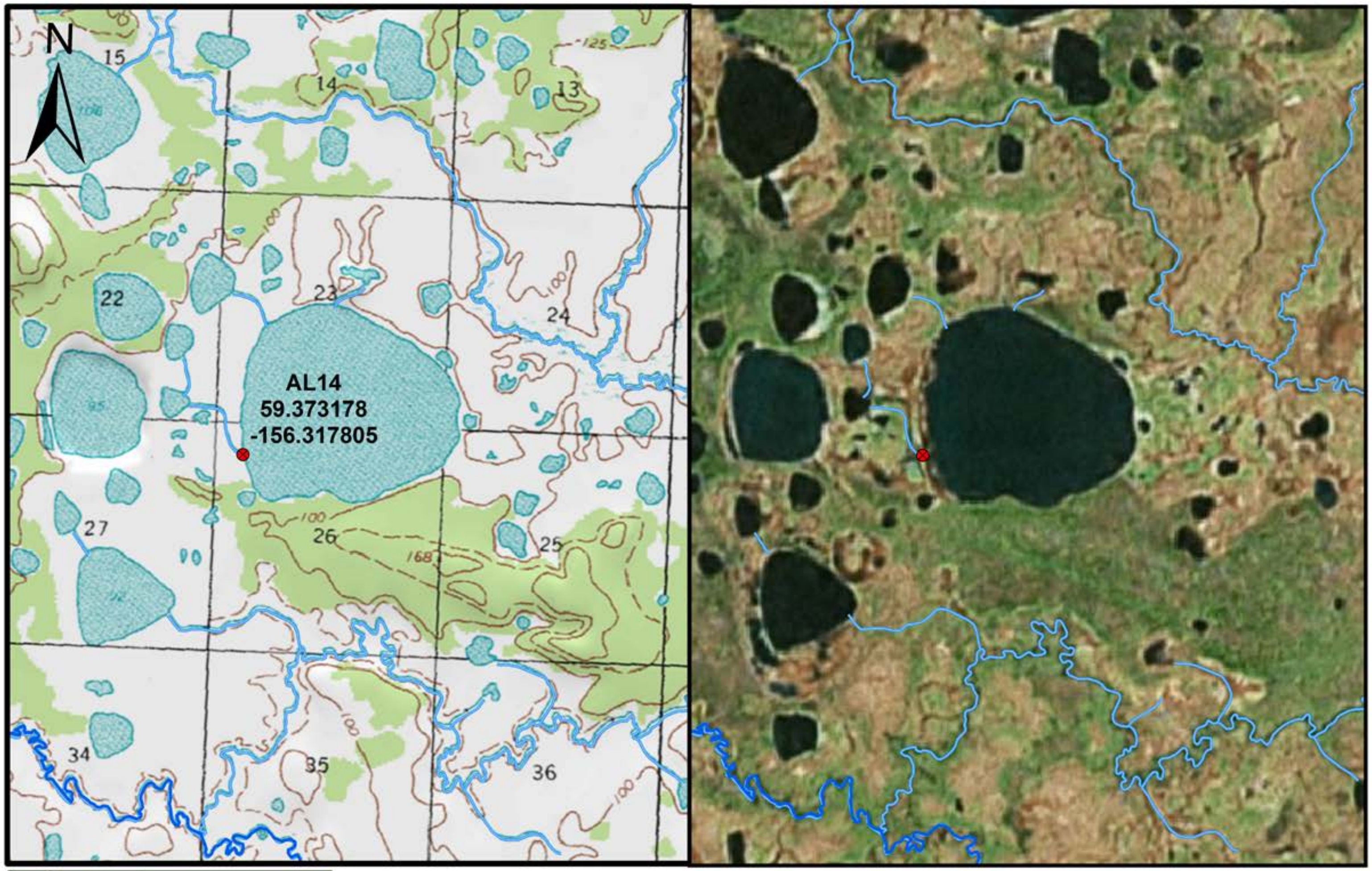
Approximate Distance to AWC Coverage (Km) = 21.36

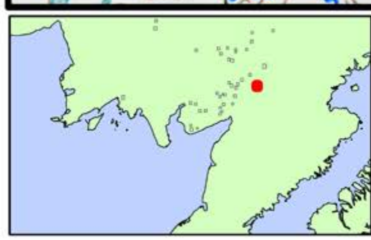
0 0.25 0.5 1 Miles

Appendix I12.–AL12.



Appendix I13.–AL13.





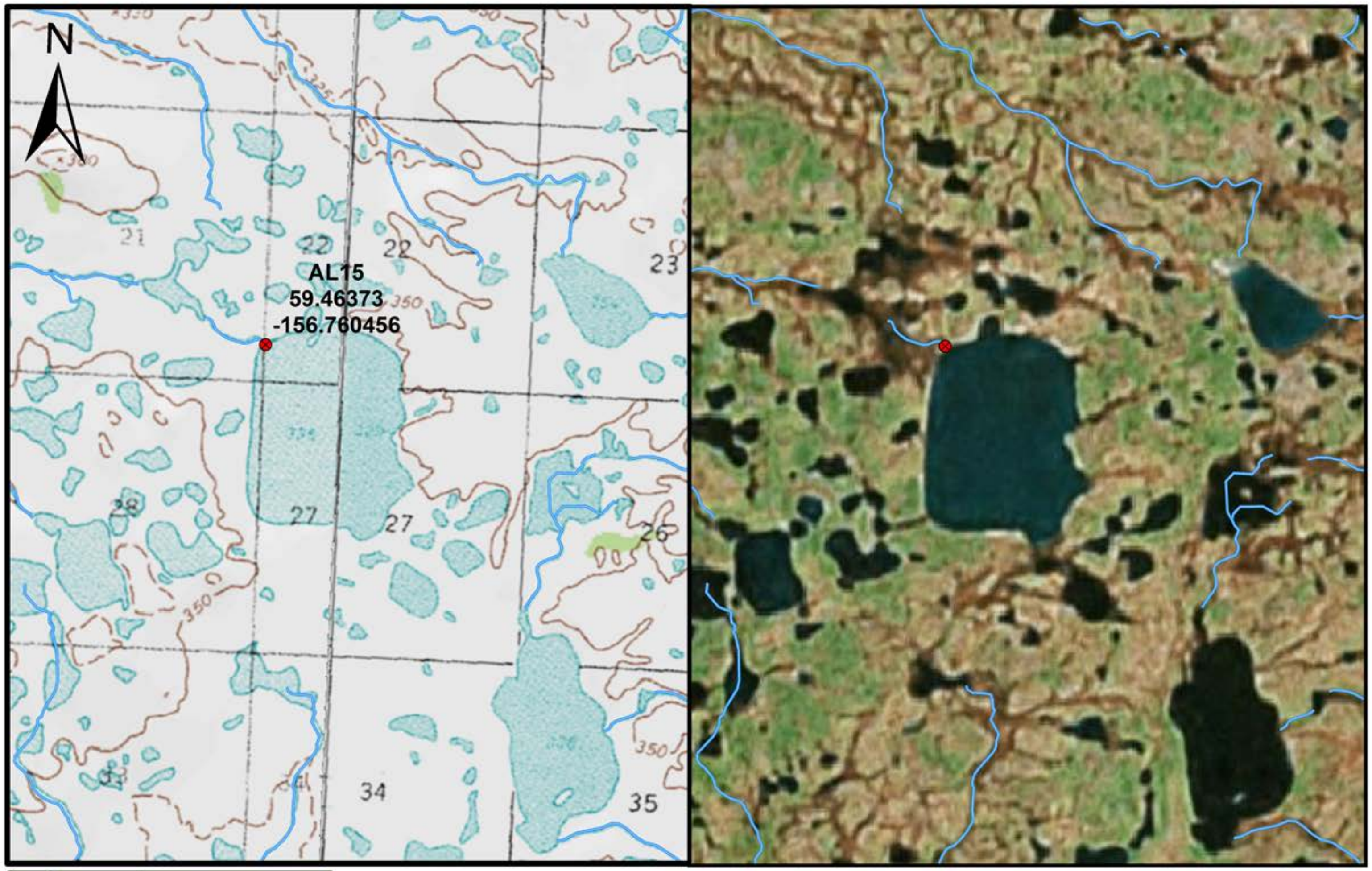
Target Lake: **AL14**

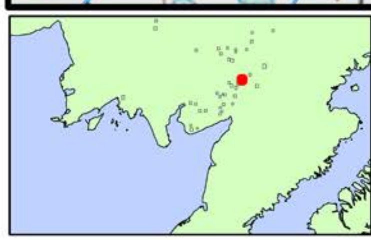
0 0.25 0.5 1 Miles

Area (Square Kilometer) = 1.68

Approximate Distance to AWC Coverage (Km) = 19.85

Appendix I14.–AL14.





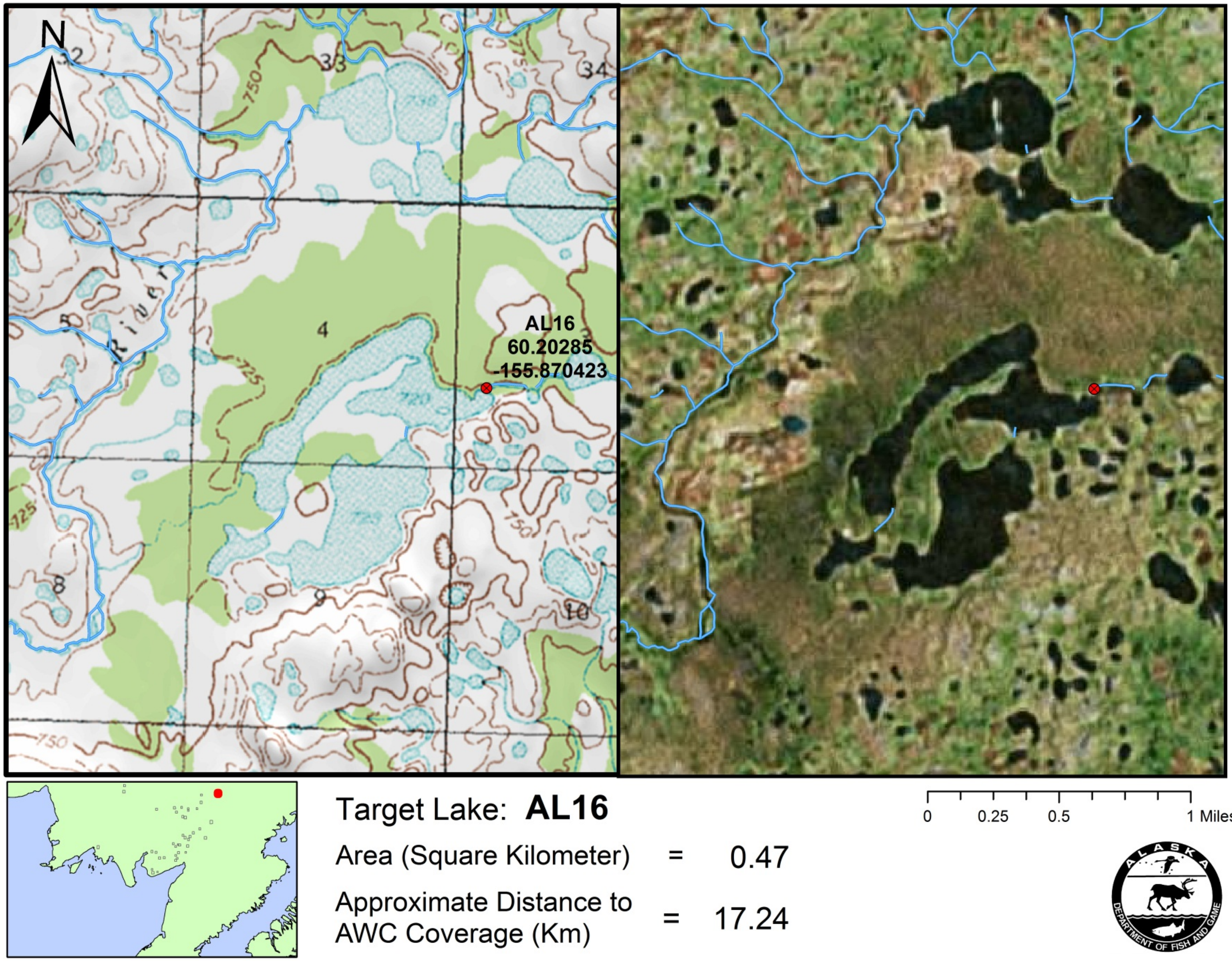
Target Lake: **AL15**

Area (Square Kilometer) = 0.99

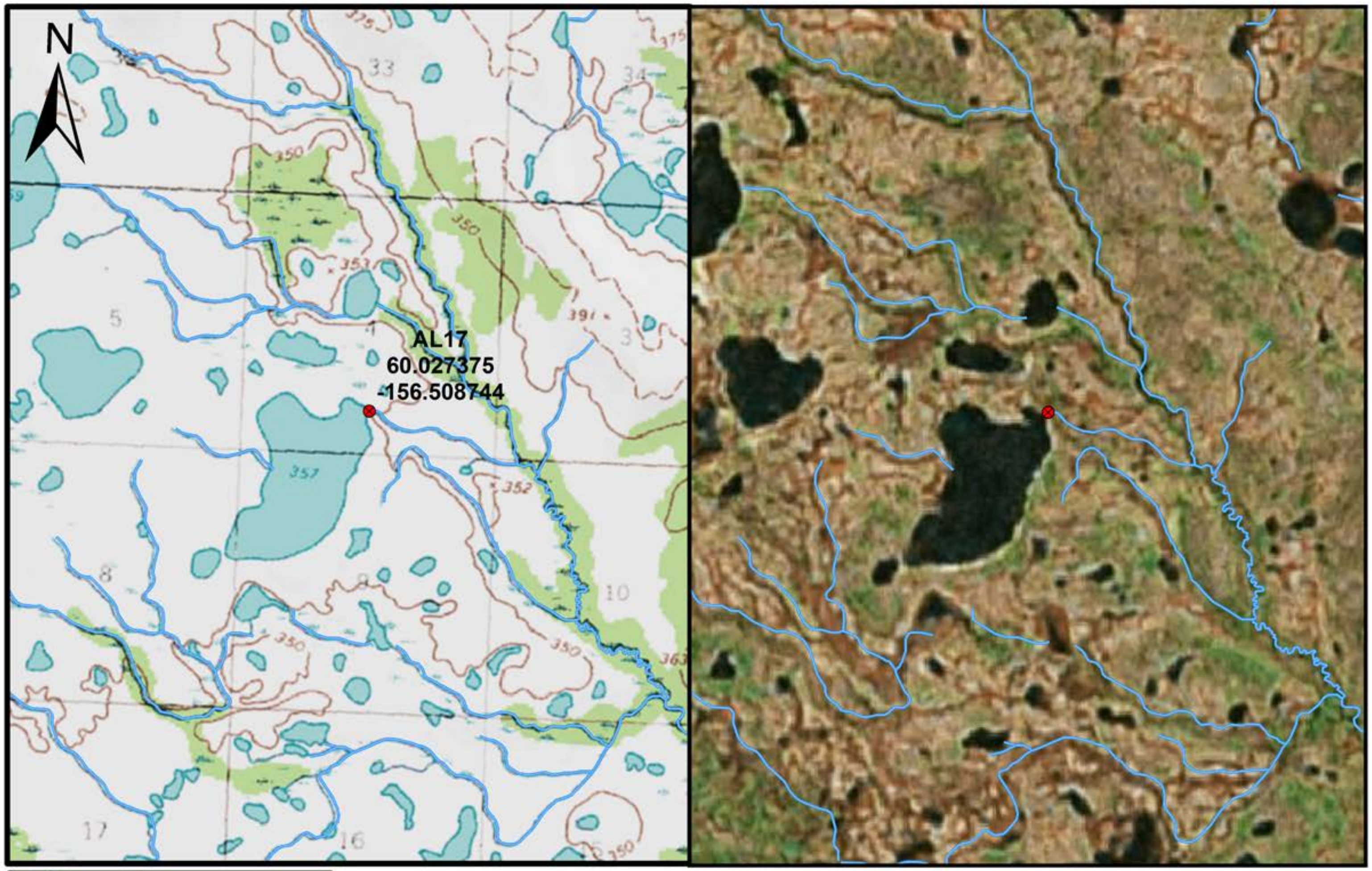
Approximate Distance to AWC Coverage (Km) = 17.9

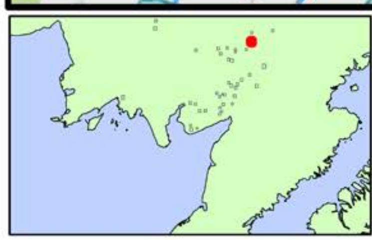
0 0.25 0.5 1 Miles

Appendix I15.–AL15.



Appendix I16.–AL16.





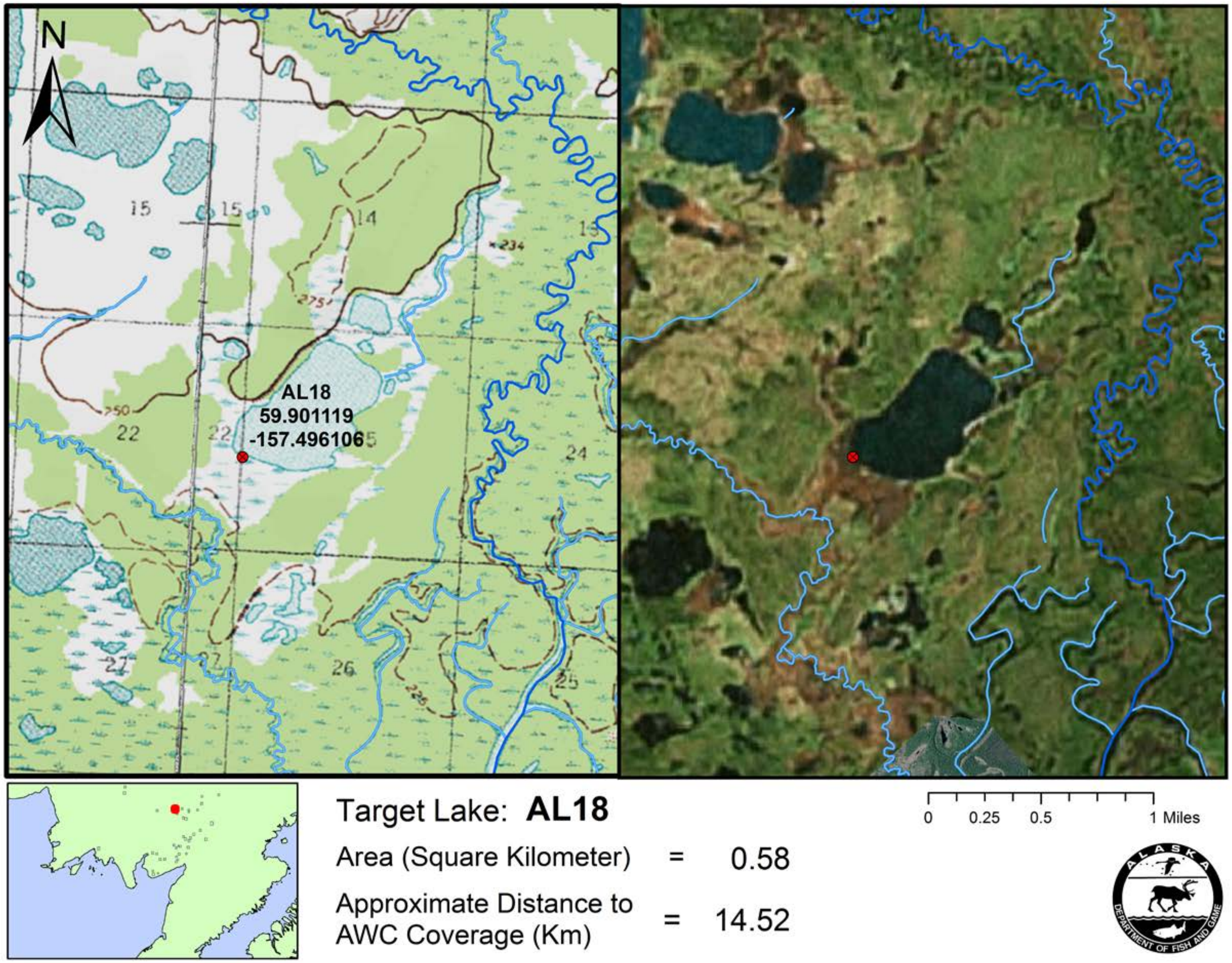
Target Lake: **AL17**

Area (Square Kilometer) = 0.56

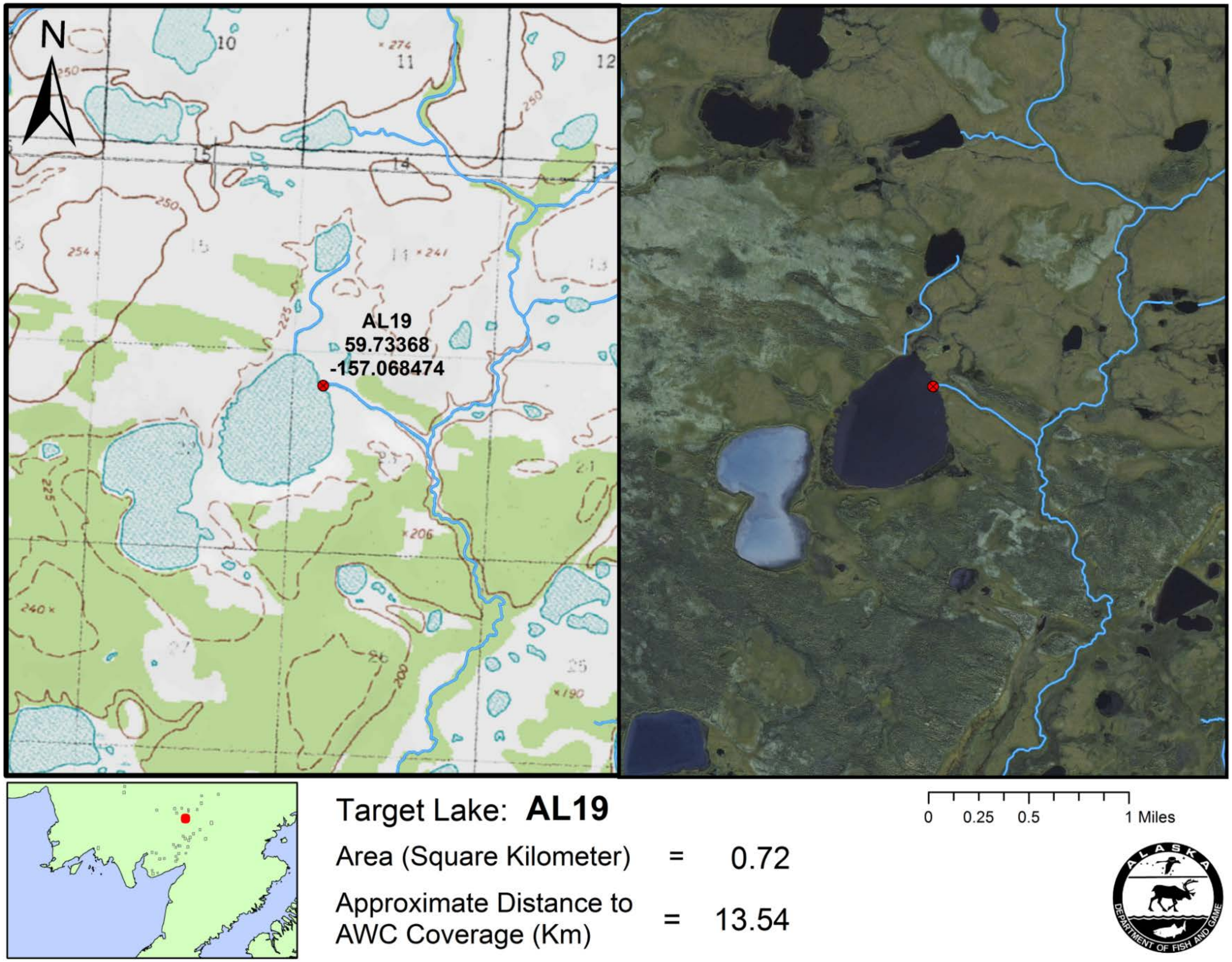
Approximate Distance to AWC Coverage (Km) = 14.73

0 0.25 0.5 1 Miles

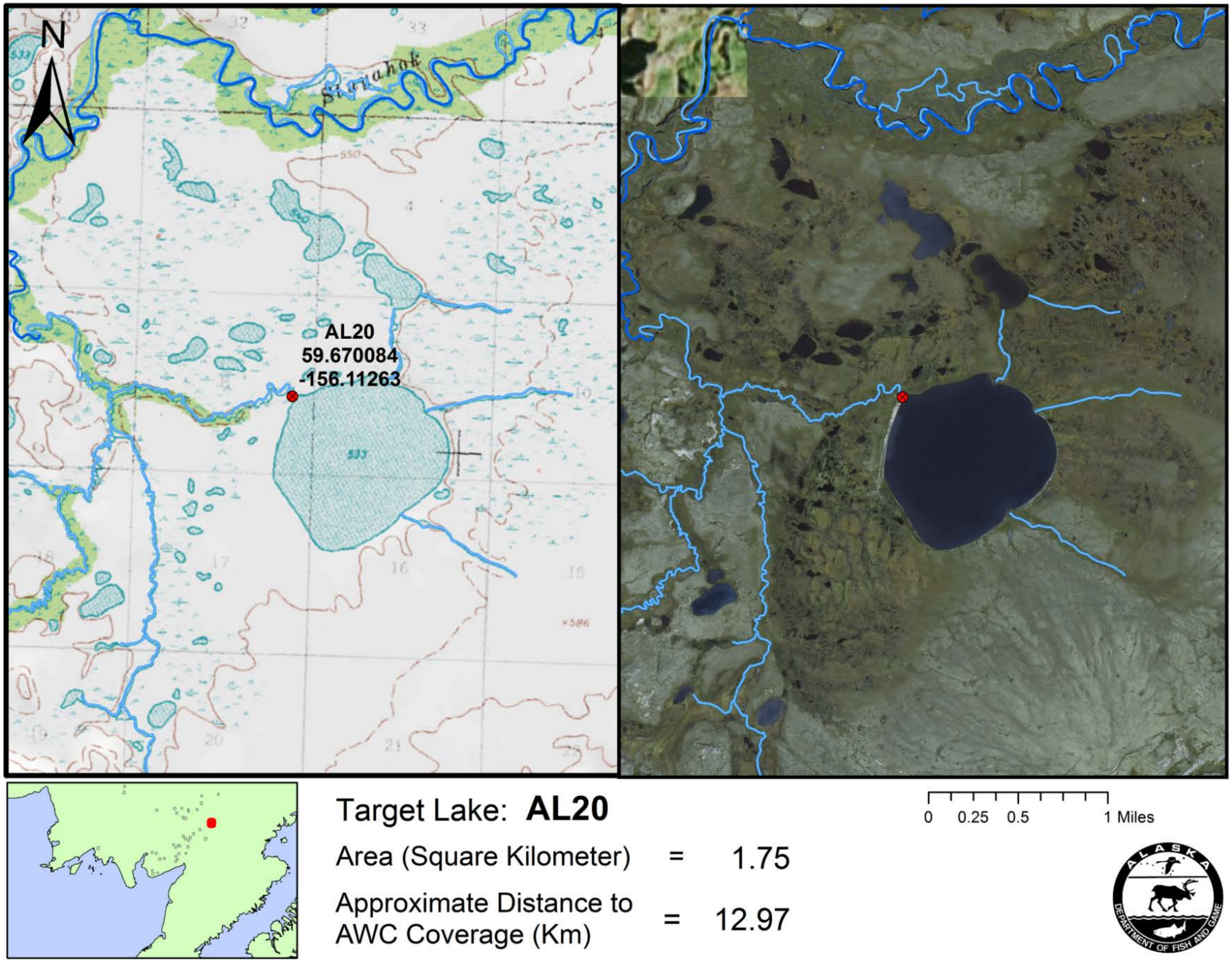
Appendix I17.–AL17.



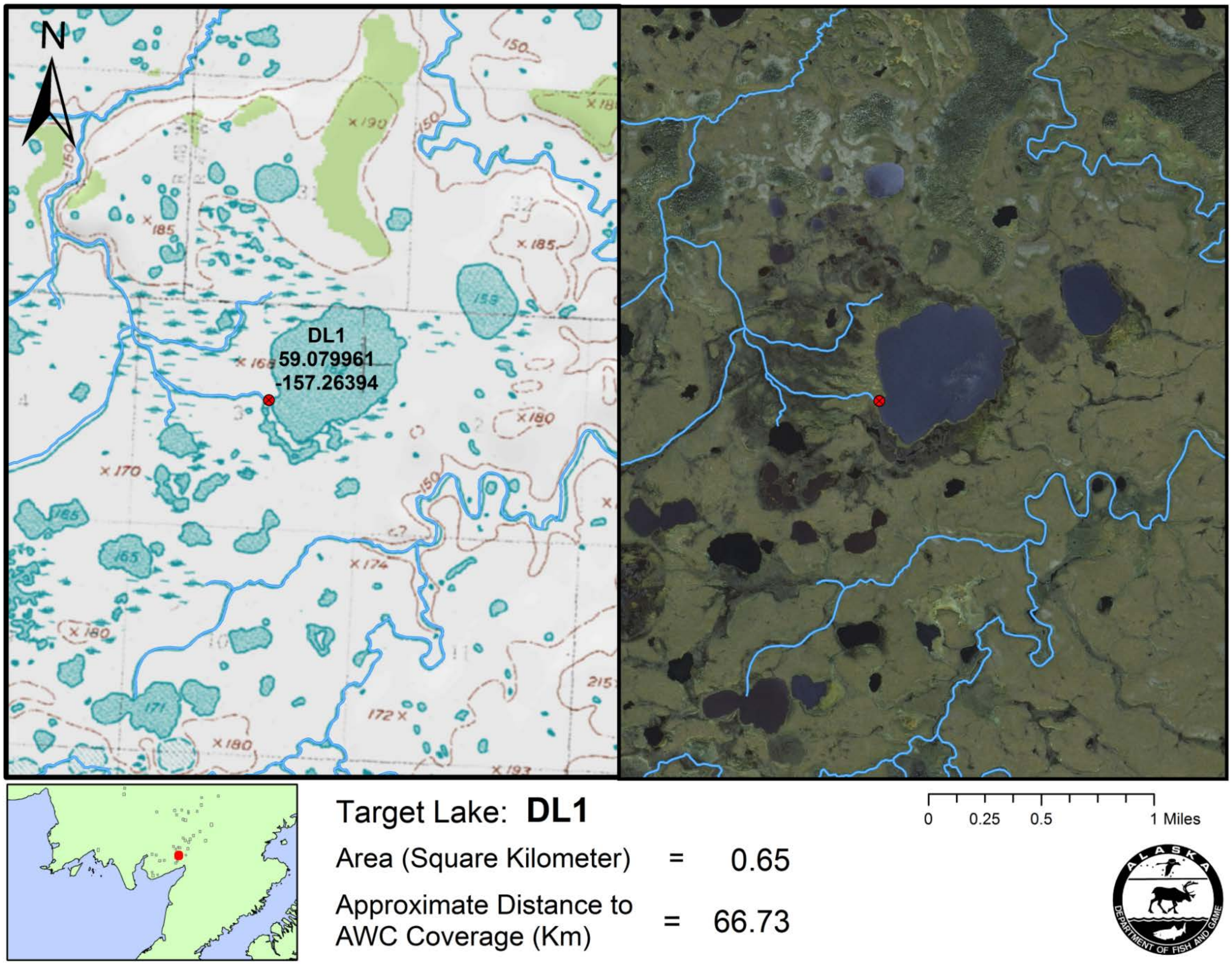
Appendix I18.–AL18.



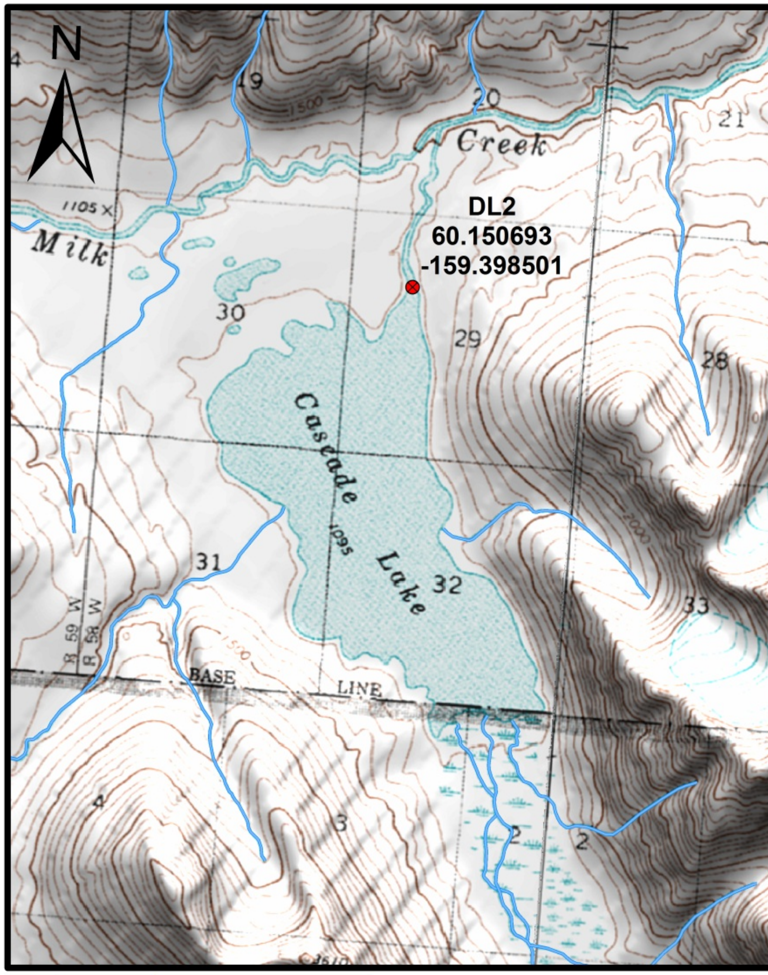
Appendix I19.–AL19.

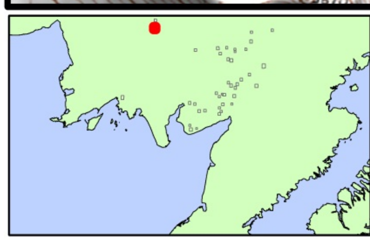


Appendix I20.–AL20.



Appendix I21.–DL1.





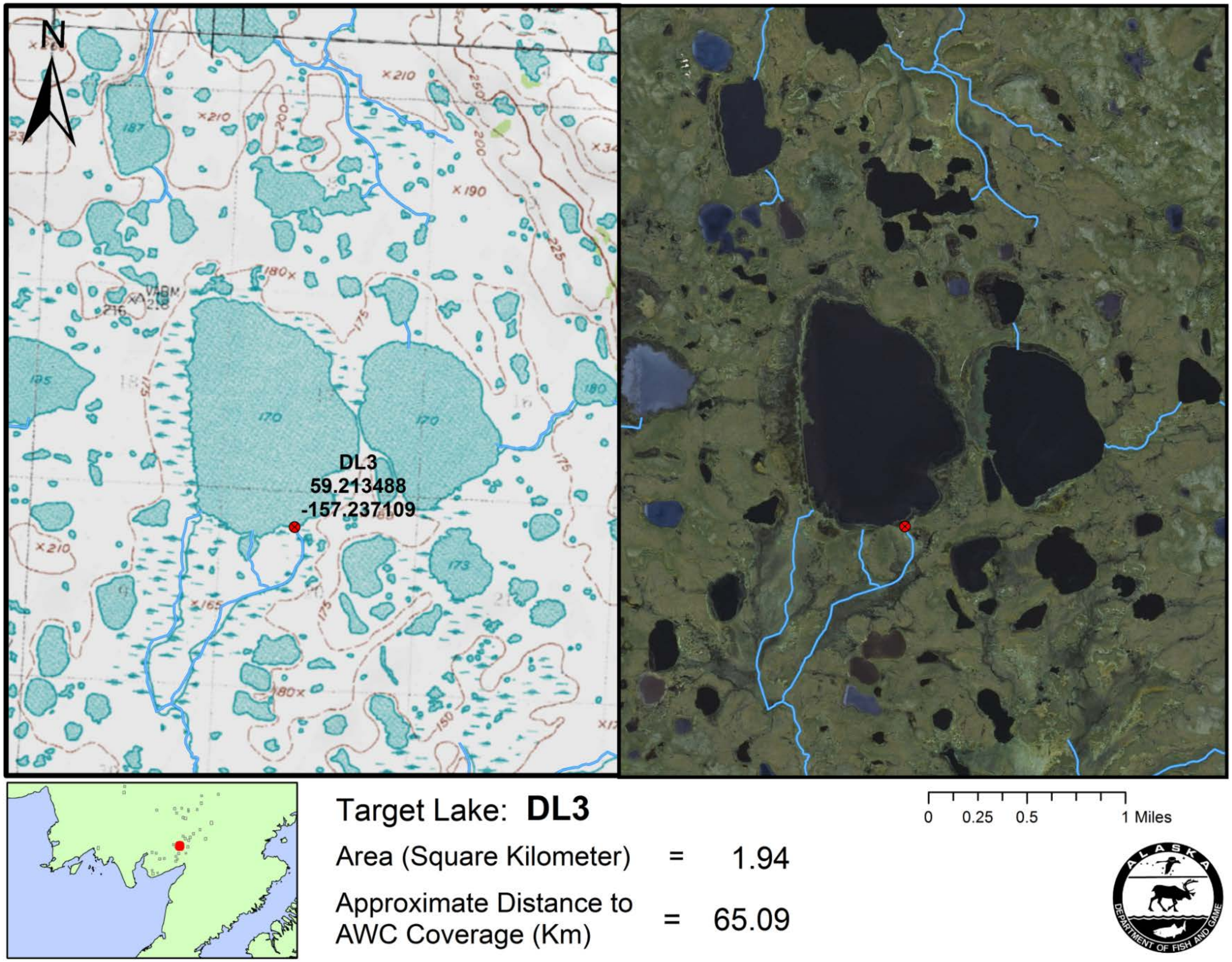
Target Lake: **DL2**

Area (Square Kilometer) = 3.11

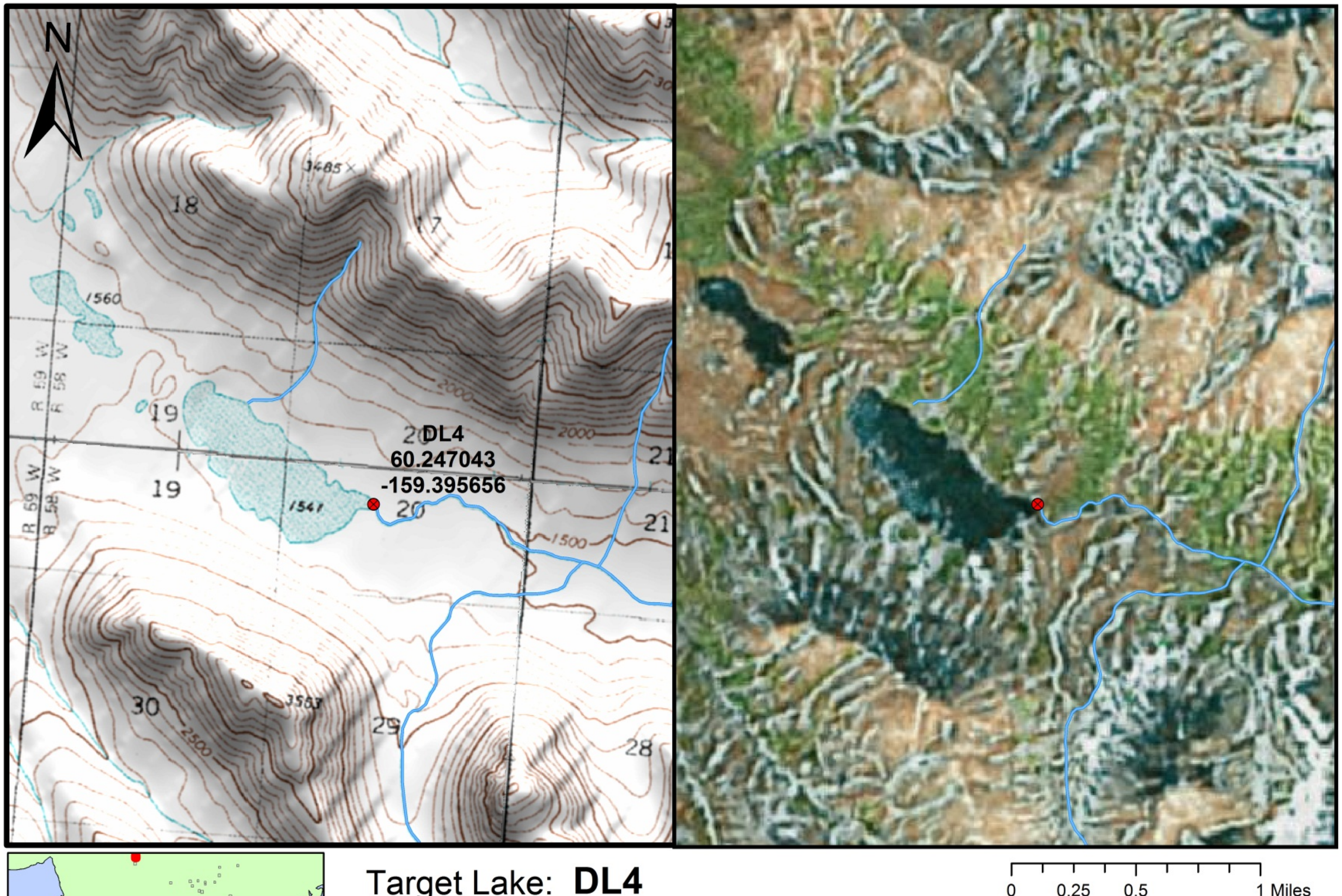
Approximate Distance to AWC Coverage (Km) = 66.33

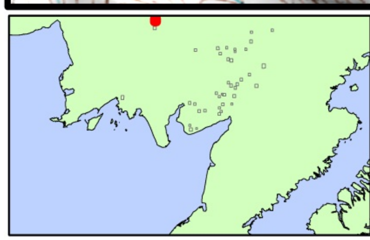
0 0.25 0.5 1 Miles

Appendix I22.–DL2.



Appendix I23.–DL3.



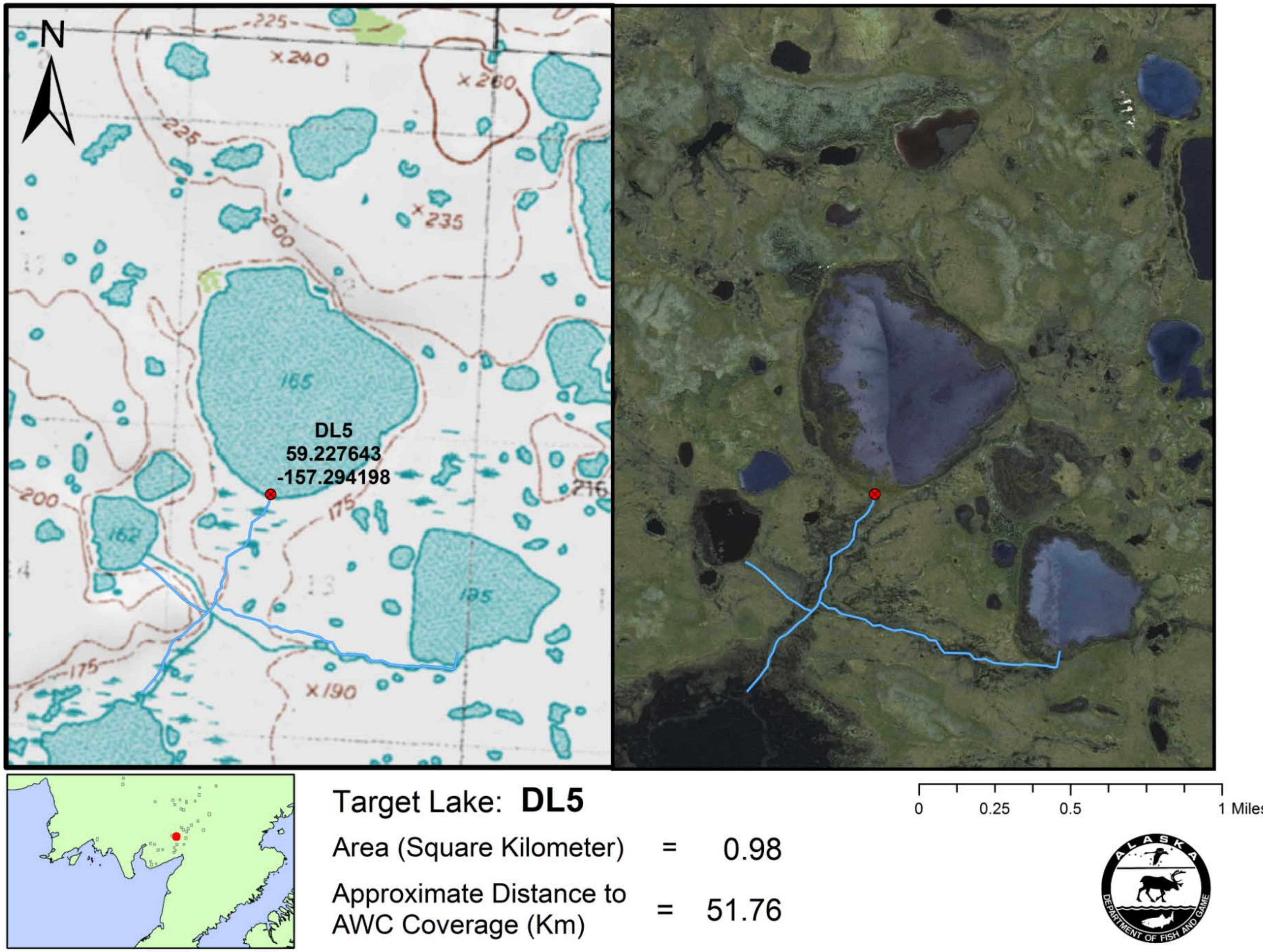


Target Lake: **DL4**

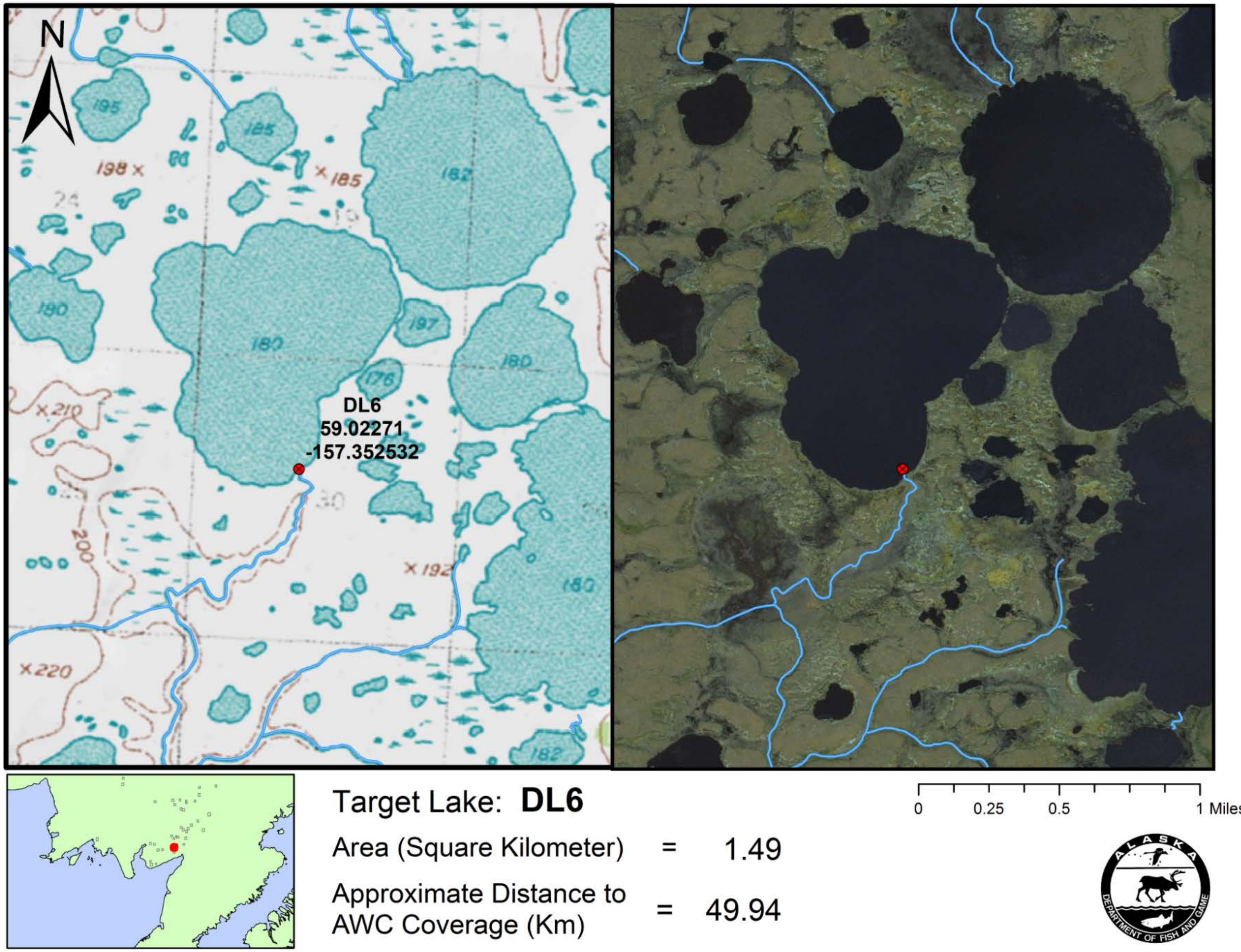
Area (Square Kilometer) = 0.56

Approximate Distance to AWC Coverage (Km) = 62.12

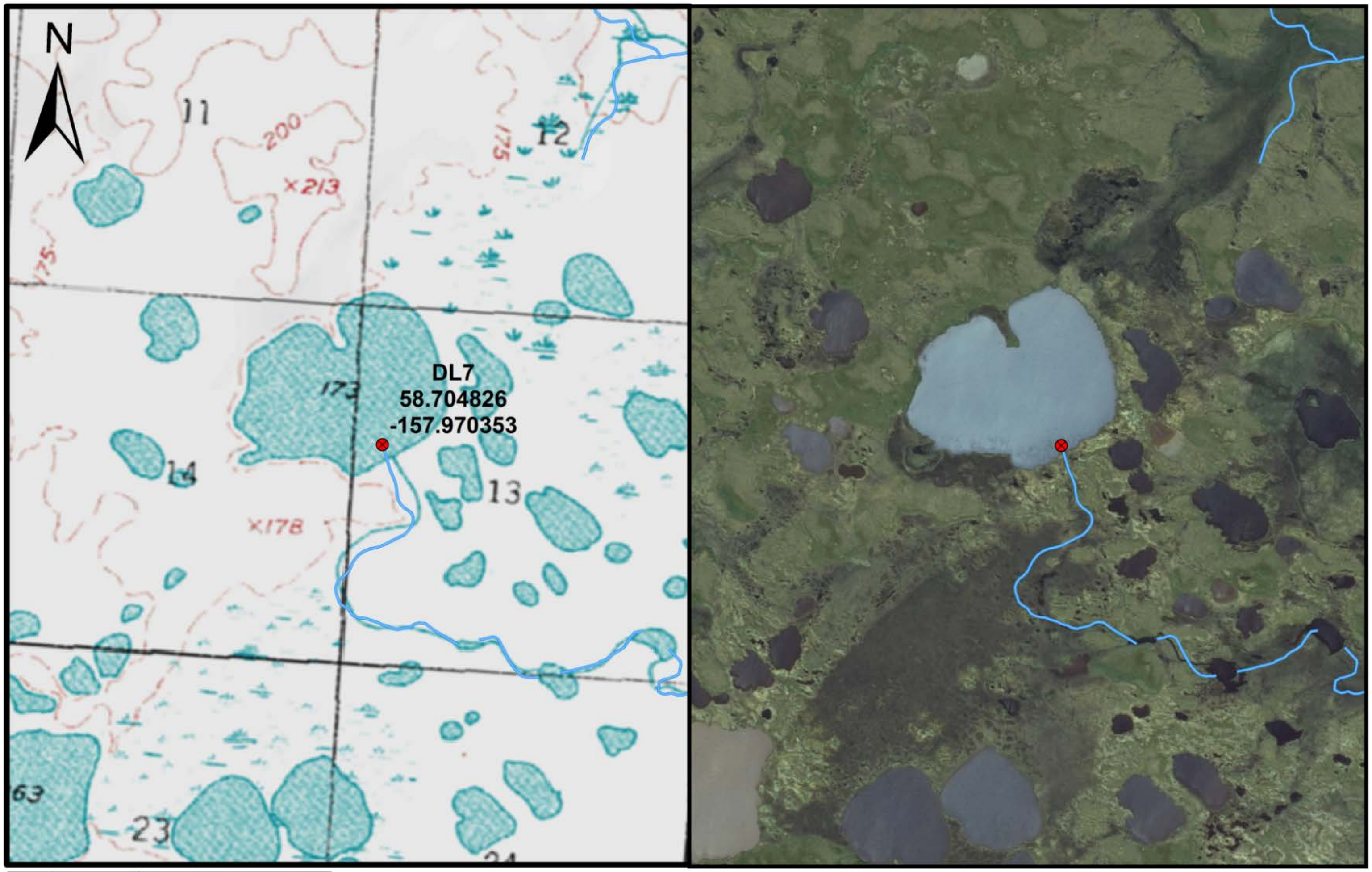
Appendix I24.–DL4.

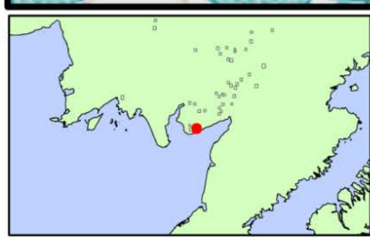


Appendix I25.–DL5.



Appendix I26.–DL6.





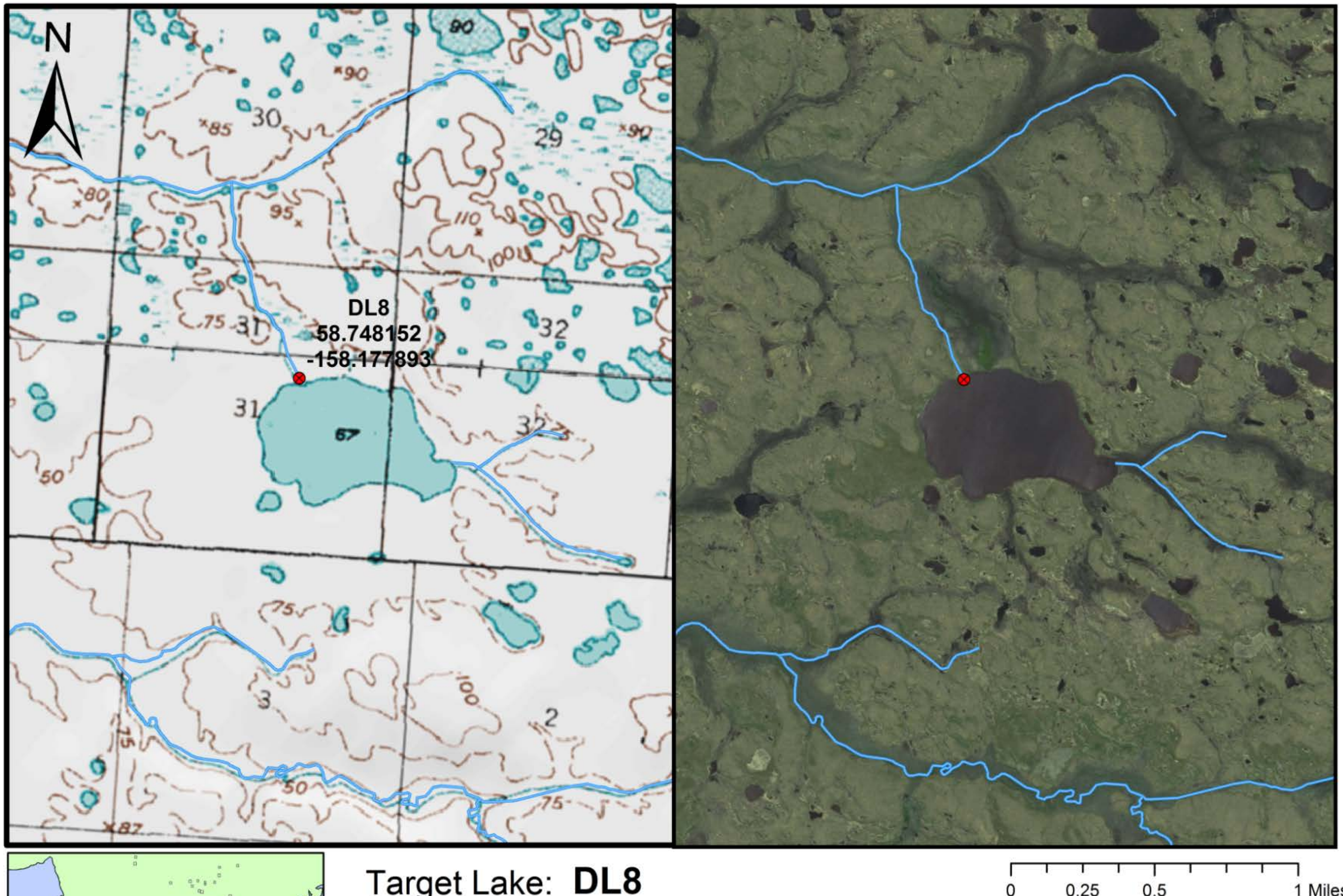
Target Lake: **DL7**

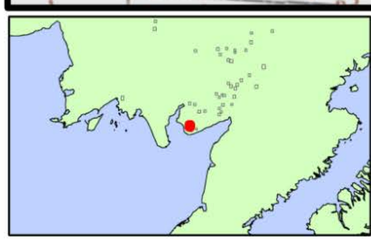
Area (Square Kilometer) = 0.51

Approximate Distance to AWC Coverage (Km) = 44.96

0 0.25 0.5 1 Miles

Appendix I27.–DL7.



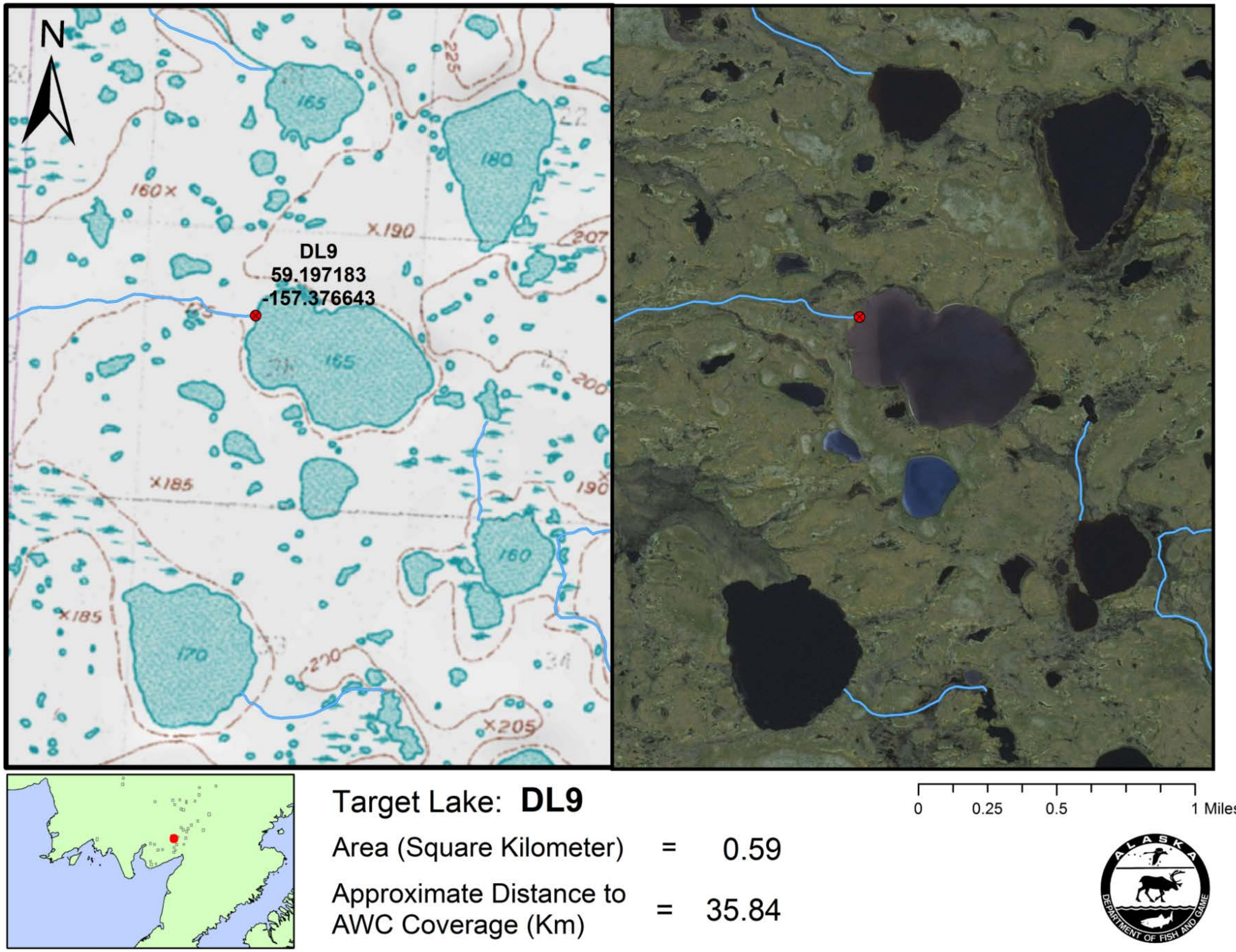


Target Lake: **DL8**

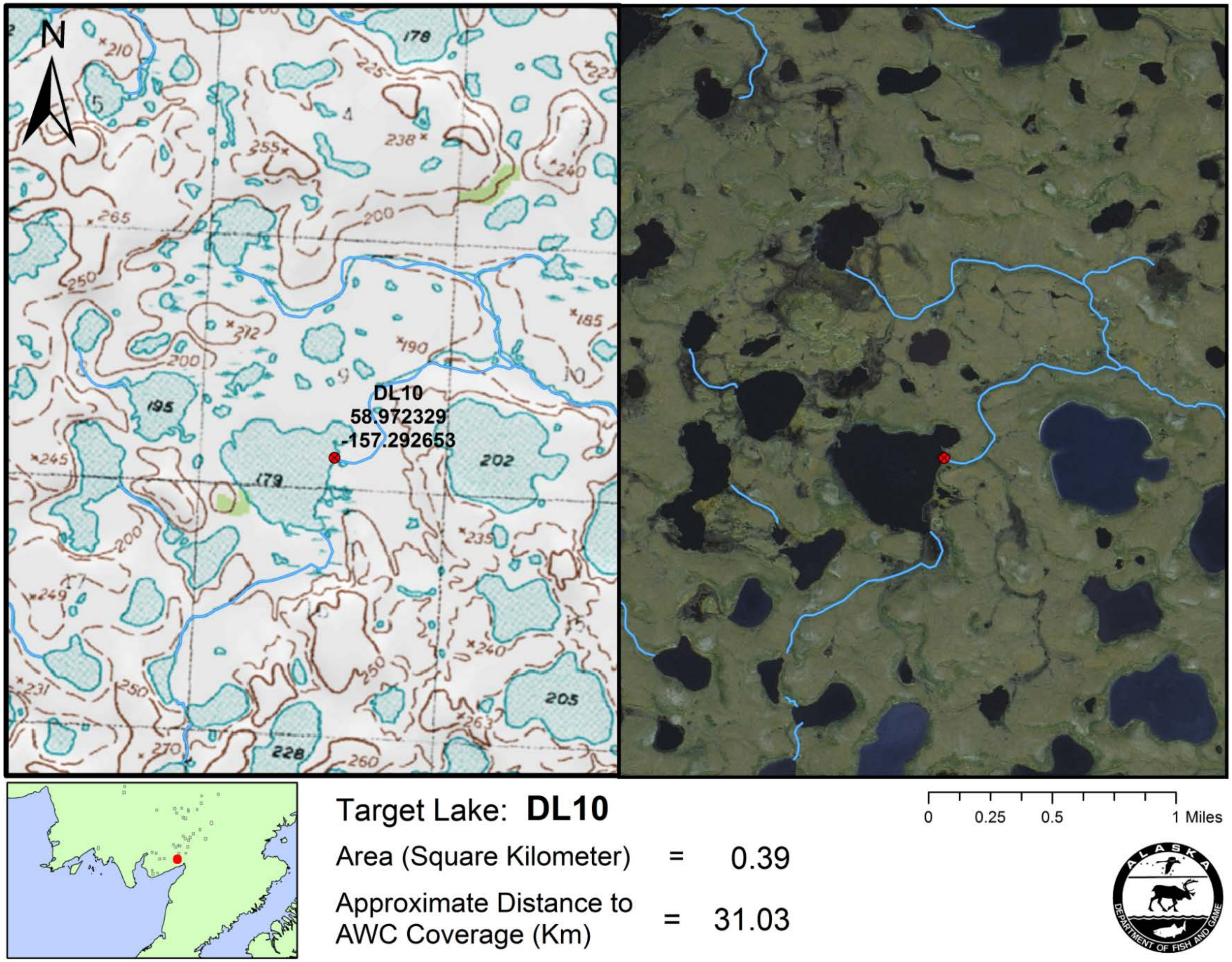
Area (Square Kilometer) = 0.55

Approximate Distance to AWC Coverage (Km) = 37.46

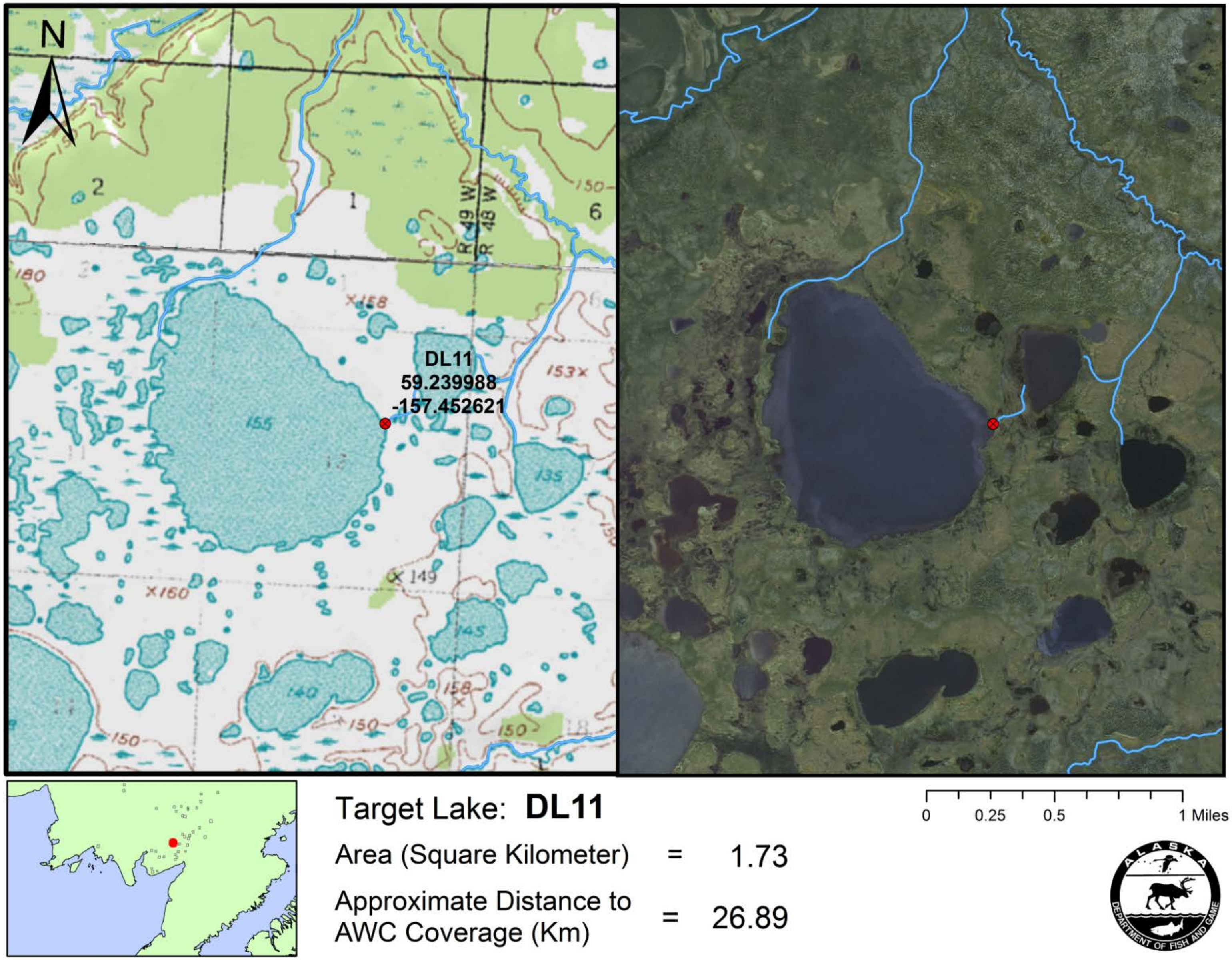
Appendix I28.–DL8.



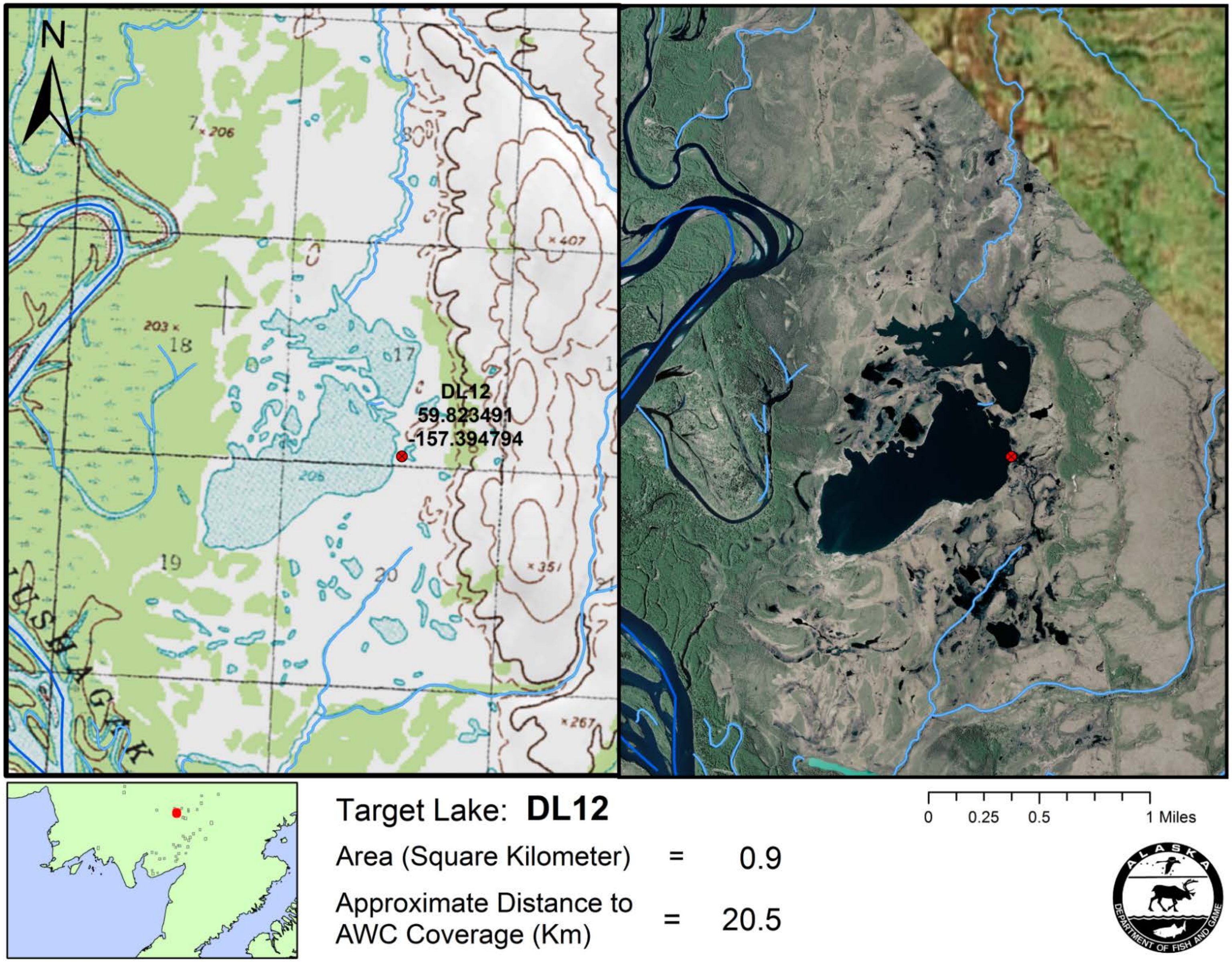
Appendix I29.–DL9.



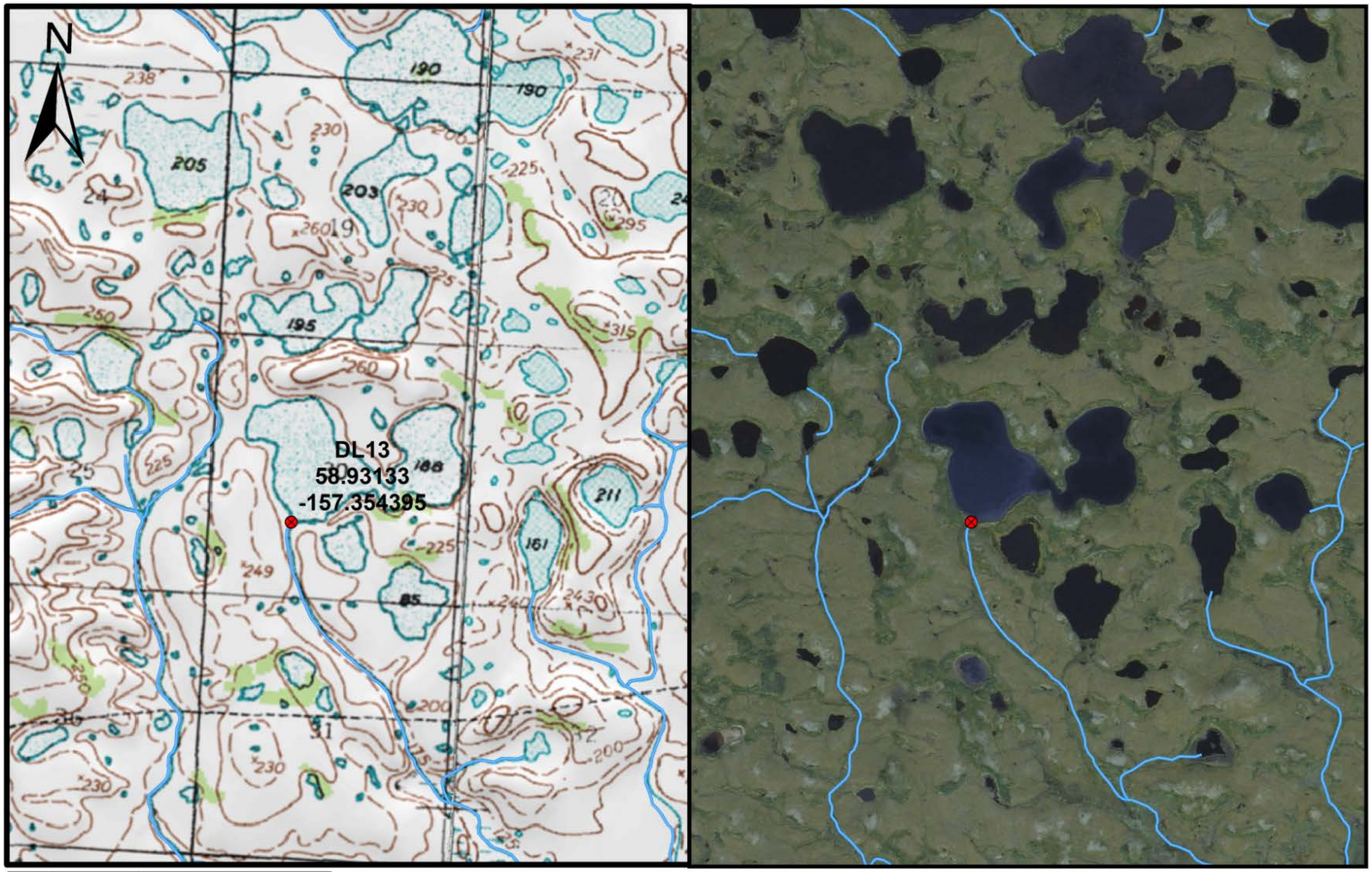
Appendix I30.–DL10.

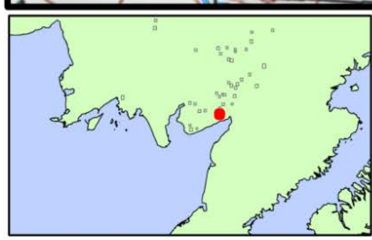


Appendix I31.–DL11.



Appendix I32.–DL12.





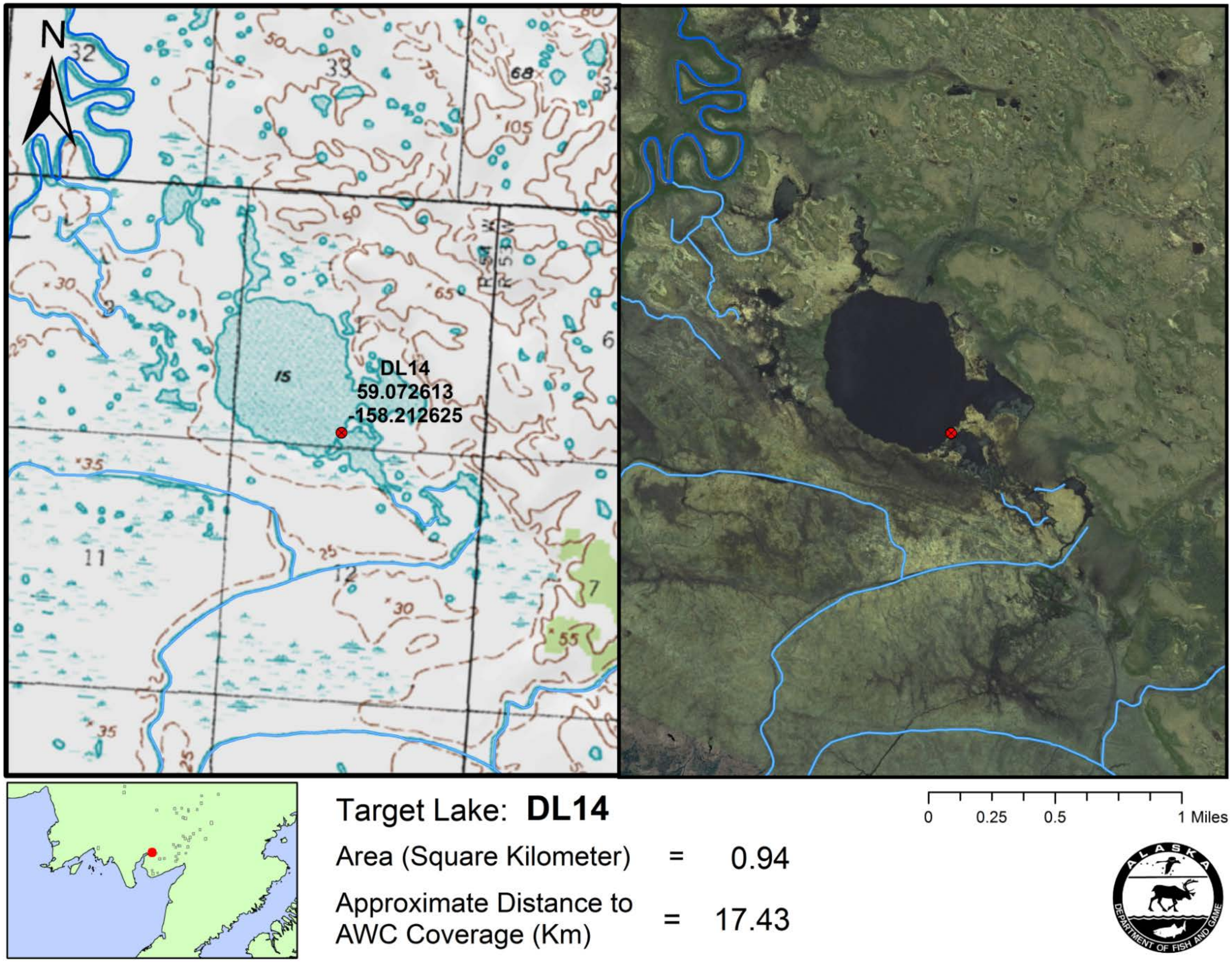
Target Lake: **DL13**

Area (Square Kilometer) = 0.59

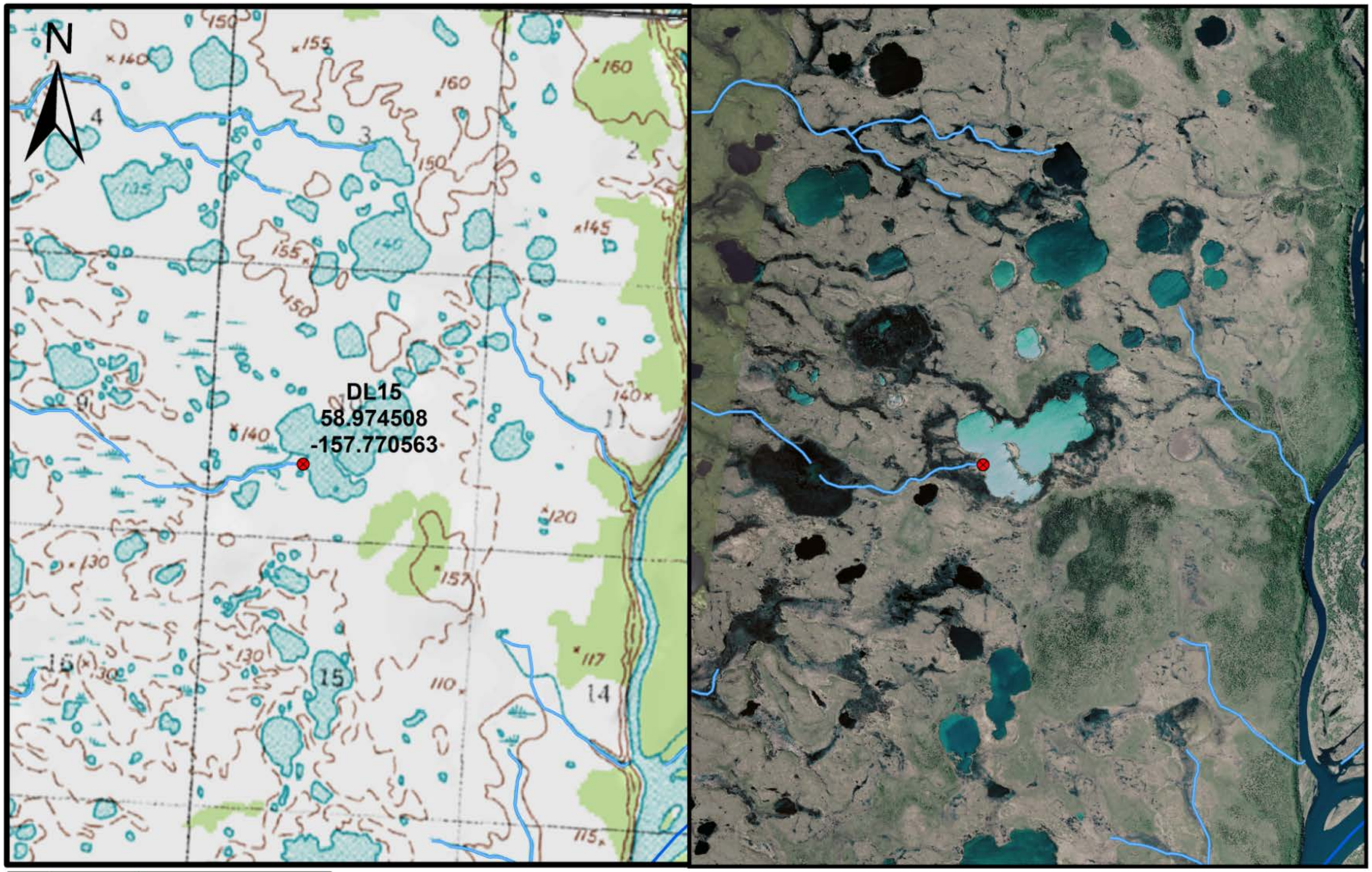
Approximate Distance to AWC Coverage (Km) = 19.1

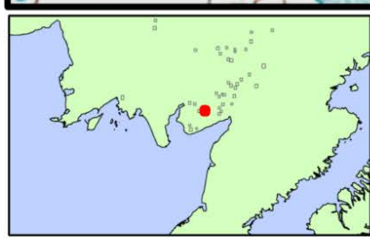
0 0.25 0.5 1 Miles

Appendix I33.–DL13.



Appendix I34.–DL14.





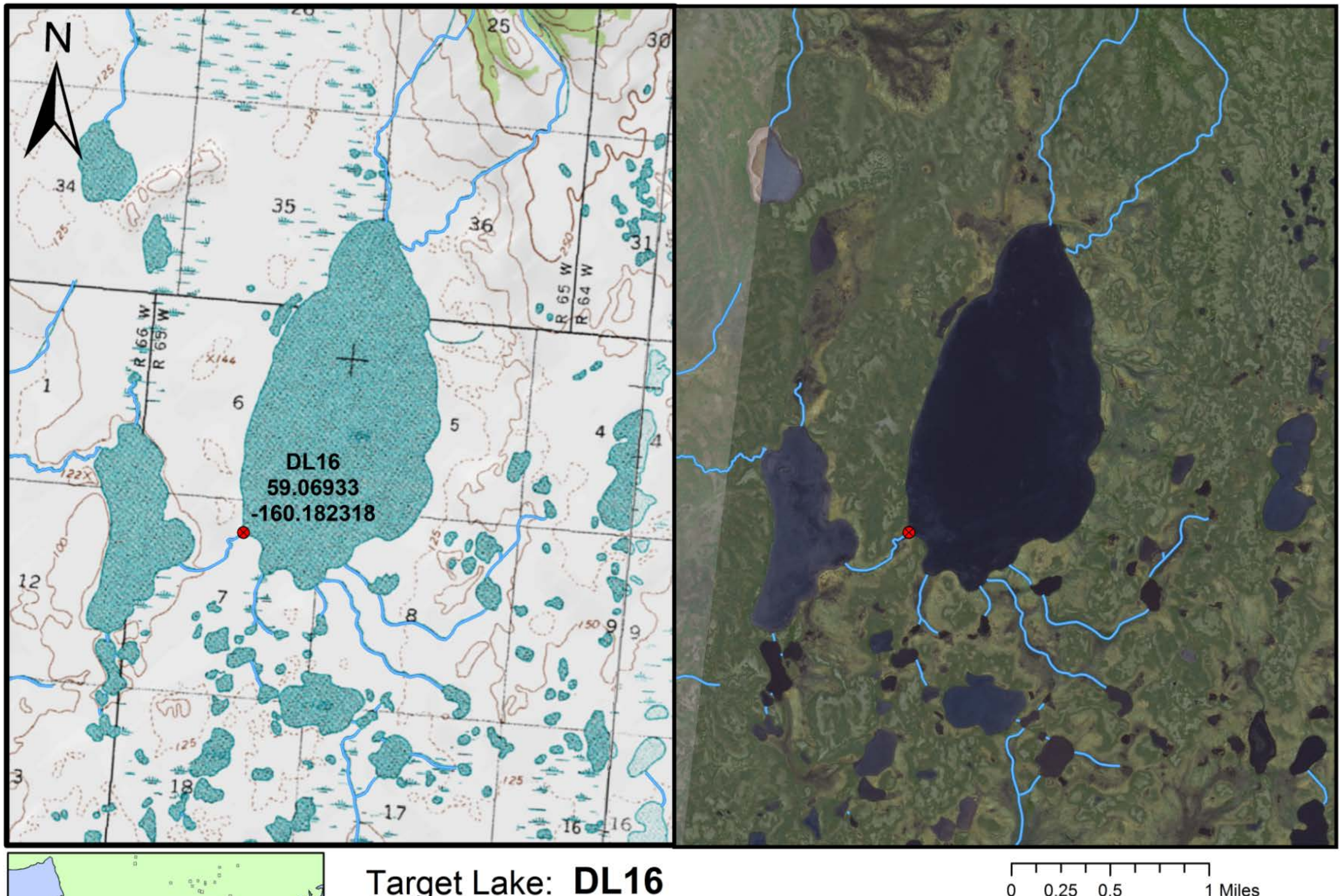
Target Lake: **DL15**

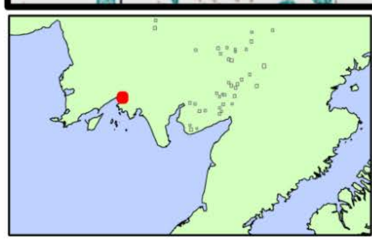
Area (Square Kilometer) = 0.27

Approximate Distance to AWC Coverage (Km) = 16.7

0 0.25 0.5 1 Miles

Appendix I35.–DL15.



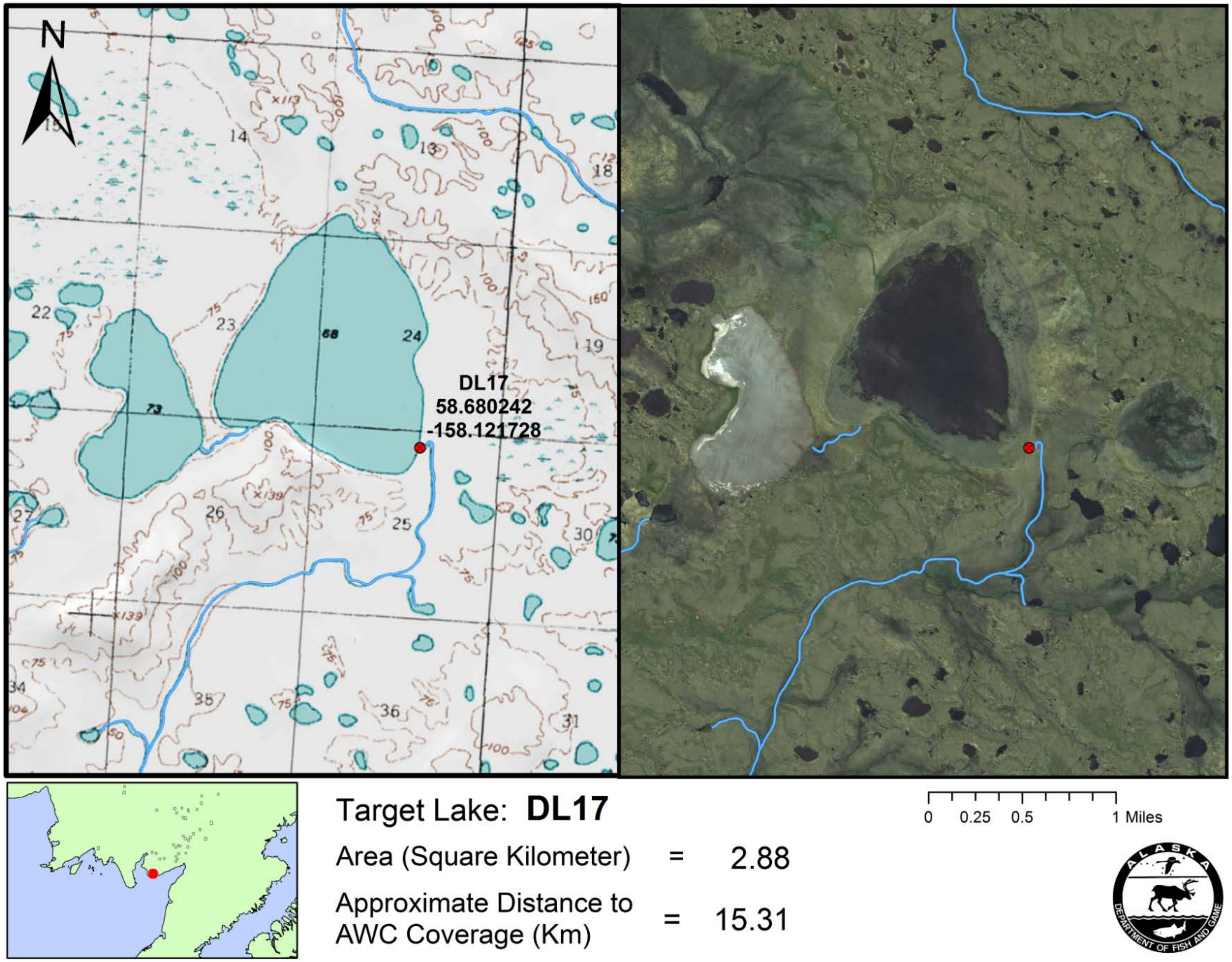


Target Lake: **DL16**

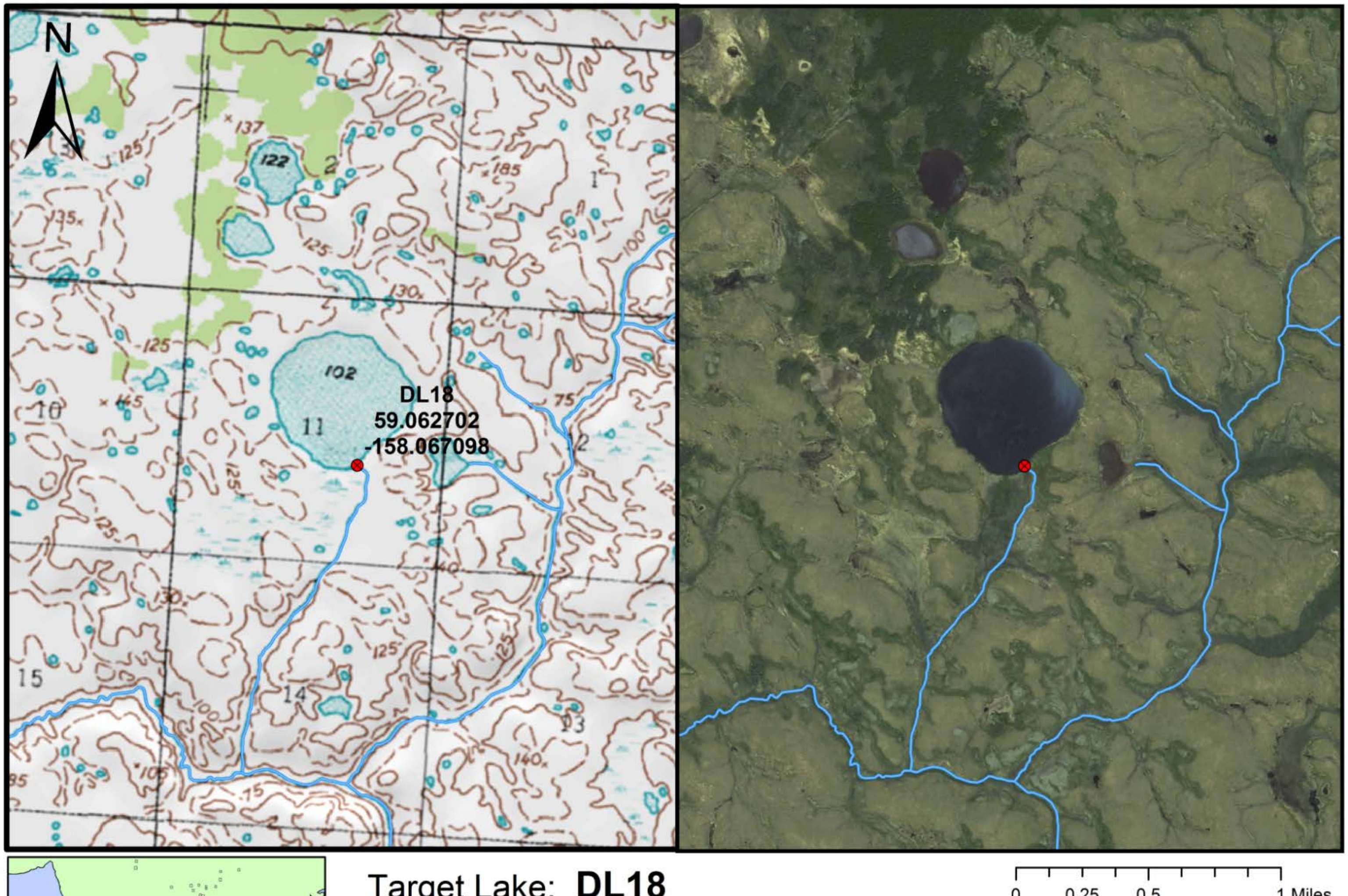
Area (Square Kilometer) = 3.3

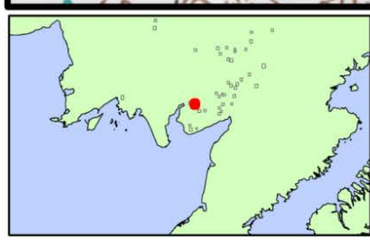
Approximate Distance to AWC Coverage (Km) = 15.54

Appendix I36.–DL16.



Appendix I37.–DL17.



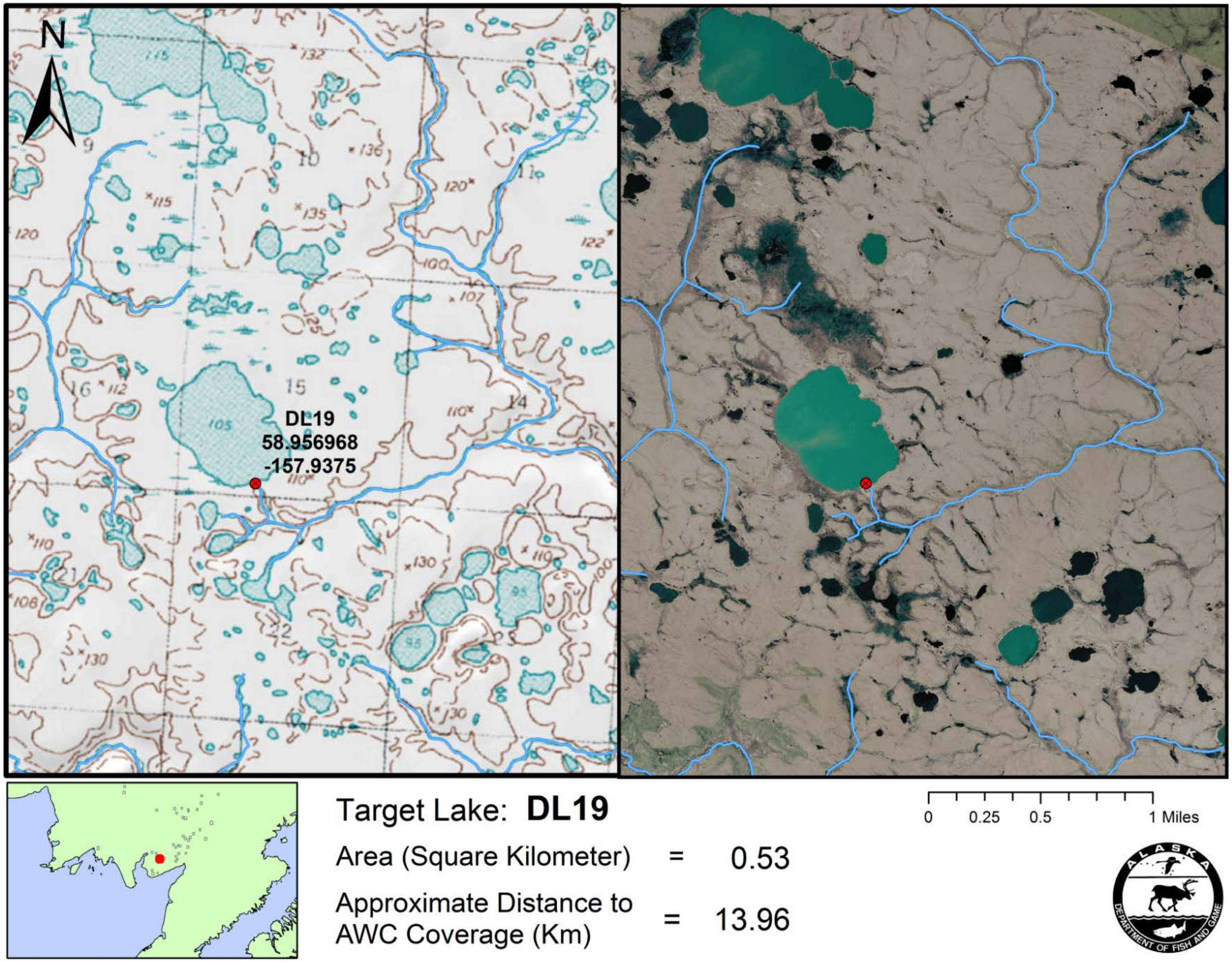


Target Lake: **DL18**

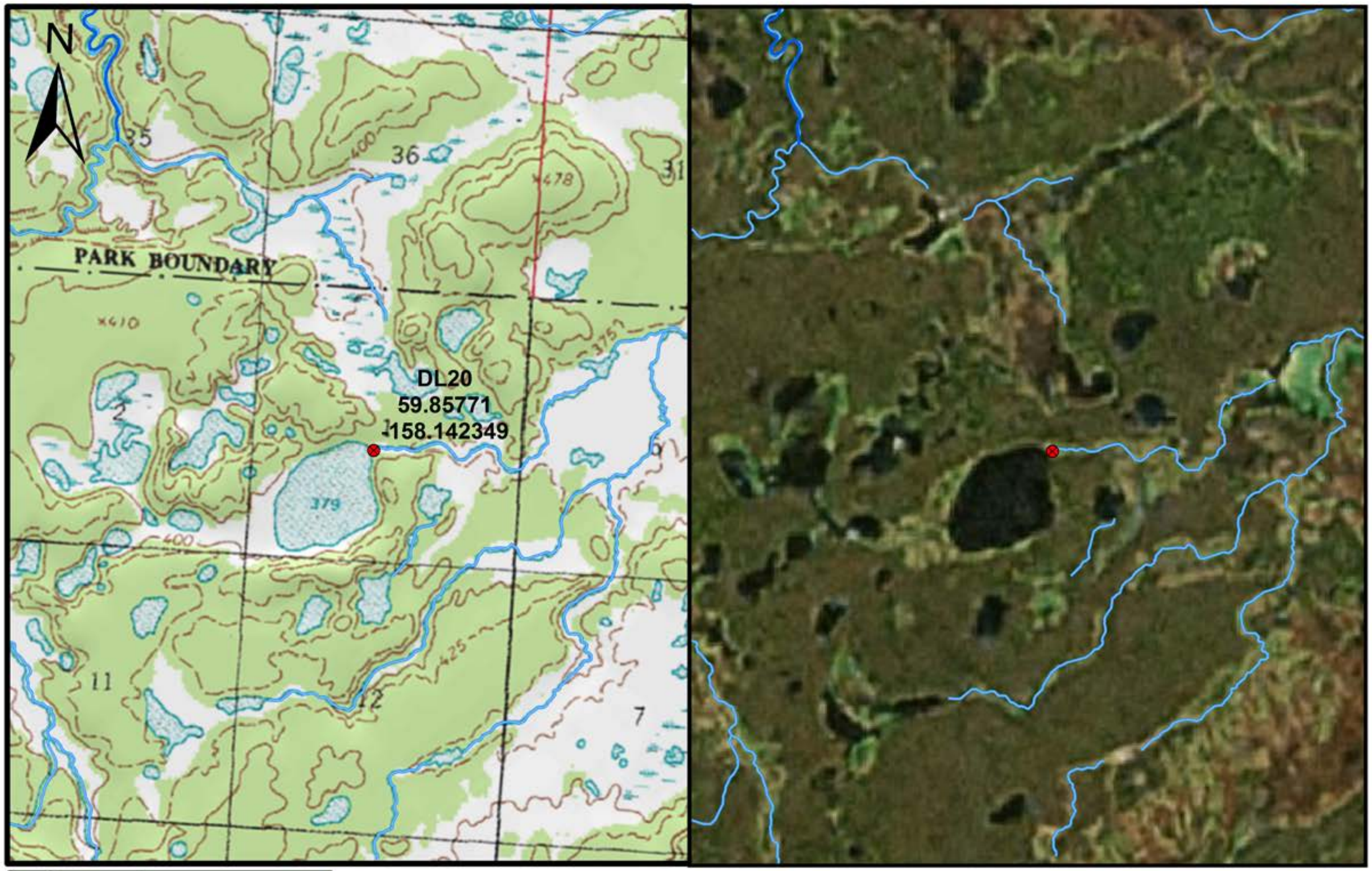
Area (Square Kilometer) = 0.51

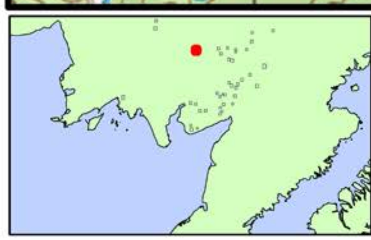
Approximate Distance to AWC Coverage (Km) = 15.29

Appendix I38.–DL18.



Appendix I39.–DL19.





Target Lake: **DL20**

0 0.25 0.5 1 Miles

Area (Square Kilometer)	=	0.29
Approximate Distance to AWC Coverage (Km)	=	13.3

Appendix I40.–DL20.